

Proposal for CP-even aQGC operator conventions

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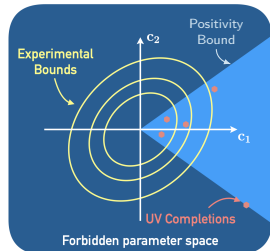
note draft [here](#)

GD, G. N. Remmen, N. L. Rodd (editors),
O. J. P. Éboli, M. C. Gonzalez-Garcia,
D. Kondo, H. Murayama, R. Okabe, M. Riebman

with oversight from LHC EFT WG conveners
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Motivation



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Facilitate the use of positivity constraints
by LHC experiments

dedicated LHC EFT WG meeting on 3 July 2023

aQGC's as most obvious target, CP-even ones in particular

- step 0: fix conventions ← we are here
- step 1: translate positivity constraints
- step 2: distribute them in some convenient form
- step 3: discuss how to take them into account

Existing literature

Almeida, Éboli, Gonzalez-Garcia, Mizukoshi '06, '16, '20

- redundancies and omissions corrected in '16 and '20
- UFO implemented here
- focused on C-even and P-even operators
- **two C-odd and P-odd operators missing**

Remmen, Rodd '19

- CP-even and -odd all listed and distinguished
- different operators than AEGM
- **one even/odd pair misidentification**

Murphy '20 (see also Li, Ren, Shu, Xiao, Yu, Zheng '20)

- same operators as RR, but different naming
- SmeftFR implementation by Dedes, Rosiek, Ryczkowski, et al. '23
- **CP-even and -odd operators not distinguished**

Kondo, Murayama, Okabe '22

- CP-even and -odd operators counted separately using Hilbert series
- **sign mistake in explicit operator property**

This note

- CP properties settled, with explanations
- minimal CP-even extension of Almeida, et al. '20
rather than following the full dim-8 basis of Murphy '20
- map to Remmen, Rodd '19 and Murphy '20
- CP-odd operators listed for completeness too
- UFO implementation of all operators [here](#)

Proposed CP-even aQGC conventions

	Operators	C P	Almeida, Éboli, Gonzalez-Garcia	Remmen & Rodd	Murphy
\mathcal{O}_0^S	$[D_\mu H^\dagger D_\nu H][D^\mu H^\dagger D^\nu H]$	+	$\mathcal{O}_{S,0}$	$\mathcal{O}_2^{H^4}$	$Q_{H^4}^{(2)}$
\mathcal{O}_1^S	$[D^\mu H^\dagger D_\mu H][D^\nu H^\dagger D_\nu H]$	+	$\mathcal{O}_{S,1}$	$\mathcal{O}_3^{H^4}$	$Q_{W^2 H^2 D^2}^{(3)}$
\mathcal{O}_2^S	$[D_\mu H^\dagger D_\nu H][D^\nu H^\dagger D^\mu H]$	+	$\mathcal{O}_{S,2}$	$\mathcal{O}_1^{H^4}$	$Q_{H^4}^{(1)}$
\mathcal{O}_0^M	$\frac{1}{2}[D^\mu H^\dagger D_\mu H]W_{\nu\rho}^I W^{\nu\rho}$	+	$\mathcal{O}_{M,0}$	$\frac{1}{2}\mathcal{O}_2^{H^2 W^2}$	$\frac{1}{2}Q_{W^2 H^2 D^2}^{(2)}$
\mathcal{O}_1^M	$-\frac{1}{2}[D^\mu H^\dagger D^\nu H]W_{\mu\rho}^I W_{\nu\rho}^I$	+	$\mathcal{O}_{M,1}$	$-\frac{1}{2}\mathcal{O}_1^{H^2 W^2}$	$-\frac{1}{2}Q_{W^2 H^2 D^2}^{(1)}$
\mathcal{O}_2^M	$[D^\mu H^\dagger D_\mu H]B_{\nu\rho} B^{\nu\rho}$	+	$\mathcal{O}_{M,2}$	$\mathcal{O}_2^{H^2 B^2}$	$Q_{B^2 H^2 D^2}^{(2)}$
\mathcal{O}_3^M	$-[D^\mu H^\dagger D^\nu H]B_{\mu\rho} B_{\nu\rho}$	+	$\mathcal{O}_{M,3}$	$-\mathcal{O}_1^{H^2 B^2}$	$-Q_{B^2 H^2 D^2}^{(1)}$
\mathcal{O}_4^M	$[D^\mu H^\dagger \tau^I D_\mu H]B^{\nu\rho} W_{\nu\rho}^I$	+	$\mathcal{O}_{M,4}$	$\mathcal{O}_1^{H^2 BW}$	$Q_{WBH^2 D^2}^{(1)}$
\mathcal{O}_5^M	$[D^\mu H^\dagger \tau^I D^\nu H](B_{\mu\nu}^\rho W_{\nu\rho}^I + B_{\nu\rho}^\rho W_{\mu\rho}^I)$	+	$\mathcal{O}_{M,5}$	$\mathcal{O}_3^{H^2 BW}$	$Q_{WBH^2 D^2}^{(4)}$
\mathcal{O}_7^M	$[D^\mu H^\dagger \tau^I \tau^J D^\nu H]W_{\mu\rho}^J W_{\nu\rho}^I$	+	$\mathcal{O}_{M,7}$	$\frac{1}{4}\mathcal{O}_1^{H^2 W^2} - \frac{1}{2}\mathcal{O}_3^{H^2 W^2}$	$\frac{1}{4}Q_{W^2 H^2 D^2}^{(1)} - \frac{1}{2}Q_{W^2 H^2 D^2}^{(4)}$
\mathcal{O}_8^M	$i[D^\mu H^\dagger \tau^I D^\nu H](B_{\nu\rho}^\rho \widetilde{W}_{\nu\rho}^I - B_{\nu\rho}^\rho \widetilde{W}_{\mu\rho}^I)$	-	—	$\widetilde{\mathcal{O}}_2^{H^2 BW}$	$Q_{WBH^2 D^2}^{(5)}$
\mathcal{O}_9^M	$\epsilon^{IJK}[D^\mu H^\dagger \tau^I D^\nu H](W_{\mu\rho}^J W_{\nu\rho}^K - \widetilde{W}_{\mu\rho}^J W_{\nu\rho}^K)$	-	—	$\widetilde{\mathcal{O}}_2^{H^2 W^2}$	$Q_{W^2 H^2 D^2}^{(5)}$
\mathcal{O}_0^T	$\frac{1}{4}W_{\mu\nu}^I W^{\mu\nu} W_{\rho\sigma}^J W^{\rho\sigma}$	+	$\mathcal{O}_{T,0}$	$\frac{1}{4}\mathcal{O}W^4$	$\frac{1}{4}Q_{W^4}^{(1)}$
\mathcal{O}_1^T	$\frac{1}{4}W_{\mu\nu}^I W_{\rho\sigma}^J W^{\mu\nu} W^{\rho\sigma}$	+	$\mathcal{O}_{T,1}$	$\frac{1}{4}\mathcal{O}W^4$	$\frac{1}{4}Q_{W^4}^{(3)}$
\mathcal{O}_2^T	$\frac{1}{4}W_{\mu\nu}^I W^{\nu\alpha} W_{\alpha\beta}^J W^{\beta\mu}$	+	$\mathcal{O}_{T,2}$	$\frac{1}{16}\mathcal{O}_1 W^4 + \frac{1}{16}\mathcal{O}_3 W^4 + \frac{1}{16}\mathcal{O}_4 W^4$	$\frac{1}{16}Q_{W^4}^{(1)} + \frac{1}{16}Q_{W^4}^{(3)} + \frac{1}{16}Q_{W^4}^{(4)}$
\mathcal{O}_3^T	$\frac{1}{4}W_{\mu\nu}^I W_{\rho\sigma}^J W^{\nu\alpha} W^{\beta\mu}$	+	$\mathcal{O}_{T,3}$	$\frac{1}{8}\mathcal{O}_3 W^4 + \frac{1}{16}\mathcal{O}_2 W^4$	$\frac{1}{8}Q_{W^4}^{(3)} + \frac{1}{16}Q_{W^4}^{(2)}$
\mathcal{O}_4^T	$\frac{1}{2}W_{\mu\nu}^I B^{\nu\alpha} W_{\alpha\beta}^J B^{\beta\mu}$	+	$\mathcal{O}_{T,4}$	$\frac{1}{8}\mathcal{O}_2 B^2 W^2 + \frac{1}{4}\mathcal{O}_3 B^2 W^2$	$\frac{1}{8}Q_{W^2 B^2}^{(2)} + \frac{1}{4}Q_{W^2 B^2}^{(3)}$
\mathcal{O}_5^T	$\frac{1}{2}B_{\mu\nu} B^{\mu\nu} W_{\rho\sigma}^I W^{\rho\sigma}$	+	$\mathcal{O}_{T,5}$	$\frac{1}{2}\mathcal{O}_1 B^2 W^2$	$\frac{1}{2}Q_{W^2 B^2}^{(1)}$
\mathcal{O}_6^T	$\frac{1}{2}B_{\mu\nu} W^{\mu\nu} B_{\rho\sigma} W^{\rho\sigma}$	+	$\mathcal{O}_{T,6}$	$\frac{1}{2}\mathcal{O}_2 B^2 W^2$	$\frac{1}{2}Q_{W^2 B^2}^{(3)}$
\mathcal{O}_7^T	$\frac{1}{2}W_{\mu\nu}^I W^{\nu\alpha} B_{\alpha\beta} B^{\beta\mu}$	+	$\mathcal{O}_{T,7}$	$\frac{1}{8}\mathcal{O}_1 B^2 W^2 + \frac{1}{8}\mathcal{O}_3 B^2 W^2 + \frac{1}{8}\mathcal{O}_4 B^2 W^2$	$\frac{1}{8}Q_{W^2 B^2}^{(1)} + \frac{1}{8}Q_{W^2 B^2}^{(3)} + \frac{1}{8}Q_{W^2 B^2}^{(4)}$
\mathcal{O}_8^T	$B_{\mu\nu} B^{\mu\nu} B_{\rho\sigma} B^{\rho\sigma}$	+	$\mathcal{O}_{T,8}$	$\mathcal{O}_1^{B^4}$	$Q_{B^4}^{(1)}$
\mathcal{O}_9^T	$B_{\mu\nu} B^{\nu\alpha} B_{\alpha\beta} B^{\beta\mu}$	+	$\mathcal{O}_{T,9}$	$\frac{1}{2}\mathcal{O}_1 B^4 + \frac{1}{4}\mathcal{O}_2 B^4$	$\frac{1}{2}Q_{B^4}^{(1)} + \frac{1}{4}Q_{B^4}^{(2)}$

\mathcal{O}_6^M not redefined (previously found to be redundant)

new \mathcal{O}_8^M and \mathcal{O}_9^M introduced

Thoughts and comments?

Extras

CP-odd aQGC's

	operators	C	P	AEG '20	RR '19	M '20
\mathcal{O}_1^M	$[D^\mu H^\dagger D_\mu H] B_{\nu\rho} \widetilde{B}^{\nu\rho}$	+	-	N/A	$\widetilde{\mathcal{O}}_1^{H^2 B^2}$	$Q_{B^2 H^2 D^2}^{(3)}$
\mathcal{O}_2^M	$[D^\mu H^\dagger \tau^I D_\mu H] B_{\nu\rho} \widetilde{W}^{I\nu\rho}$	+	-	N/A	$\widetilde{\mathcal{O}}_1^{H^2 BW}$	$Q_{WBH^2 D^2}^{(2)}$
\mathcal{O}_3^M	$i[D^\mu H^\dagger \tau^I D^\nu H] (B_{\mu\rho} \widetilde{W}_\nu^I{}^\rho - B_{\nu\rho} \widetilde{W}_\mu^I{}^\rho)$	-	+	N/A	$\mathcal{O}_2^{H^2 BW}$	$Q_{WBH^2 D^2}^{(3)}$
\mathcal{O}_4^M	$[D^\mu H^\dagger \tau^I D^\nu H] (B_{\mu\rho} \widetilde{W}_\nu^I{}^\rho + B_{\nu\rho} \widetilde{W}_\mu^I{}^\rho)$	+	-	N/A	$\widetilde{\mathcal{O}}_3^{H^2 BW}$	$Q_{WBH^2 D^2}^{(6)}$
\mathcal{O}_5^M	$[D^\mu H^\dagger D_\mu H] W_{\nu\rho}^I \widetilde{W}^{I\nu\rho}$	+	-	N/A	$\widetilde{\mathcal{O}}_1^{H^2 W^2}$	$Q_{W^2 H^2 D^2}^{(3)}$
\mathcal{O}_6^M	$i \epsilon^{\mu\nu\rho\sigma} [D^\mu H^\dagger \tau^I D^\nu H] (W_{\mu\rho}^J \widetilde{W}_\nu^K{}^\rho + \widetilde{W}_{\mu\rho}^J W_\nu^K{}^\rho)$	+	-	N/A	$\widetilde{\mathcal{O}}_3^{H^2 W^2}$	$Q_{W^2 H^2 D^2}^{(6)}$
\mathcal{O}_1^T	$B_{\mu\nu} B^{\mu\nu} B_{\rho\sigma} \widetilde{B}^{\rho\sigma}$	+	-	N/A	$\widetilde{\mathcal{O}}_1^{B^4}$	$Q_{B^4}^{(3)}$
\mathcal{O}_2^T	$B_{\mu\nu} \widetilde{B}^{\mu\nu} W_{\rho\sigma}^I W^{I\rho\sigma}$	+	-	N/A	$\widetilde{\mathcal{O}}_1^{B^2 W^2}$	$Q_{W^2 B^2}^{(5)}$
\mathcal{O}_3^T	$B_{\mu\nu} B^{\mu\nu} W_{\rho\sigma}^I \widetilde{W}^{I\rho\sigma}$	+	-	N/A	$\widetilde{\mathcal{O}}_2^{B^2 W^2}$	$Q_{W^2 B^2}^{(6)}$
\mathcal{O}_4^T	$B_{\mu\nu} W^{I\mu\nu} B_{\rho\sigma} \widetilde{W}^{I\rho\sigma}$	+	-	N/A	$\widetilde{\mathcal{O}}_3^{B^2 W^2}$	$Q_{W^2 B^2}^{(7)}$
\mathcal{O}_5^T	$W_{\mu\nu}^I W^{I\mu\nu} W_{\rho\sigma}^J \widetilde{W}^{J\rho\sigma}$	+	-	N/A	$\widetilde{\mathcal{O}}_1^{W^4}$	$Q_{W^4}^{(5)}$
\mathcal{O}_6^T	$W_{\mu\nu}^I W^{J\mu\nu} W_{\rho\sigma}^I \widetilde{W}^{J\rho\sigma}$	+	-	N/A	$\widetilde{\mathcal{O}}_2^{W^4}$	$Q_{W^4}^{(6)}$

same operators as RR' 19 and M '20