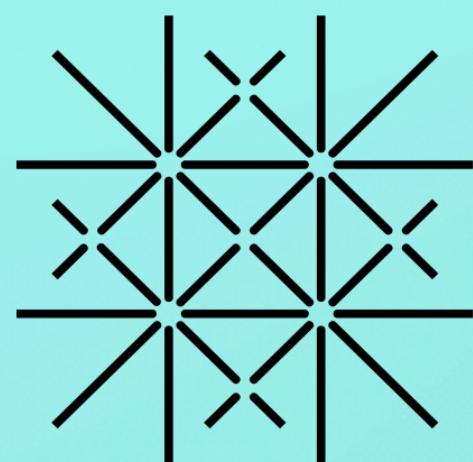


Discrete Leptonic Flavor Symmetries in the SMEFT

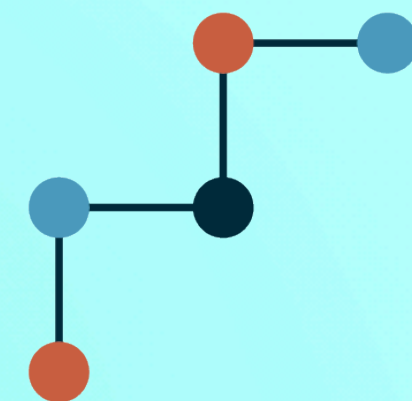
Ajdin Palavrić

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Dimension-6 SMEFT

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- Model-independent \implies large # of independent parameters

Dimension-6 SMEFT

- Model-independent \implies large # of independent parameters
- Dimension-6 basis
 - Single generation: 59 parameters
 - Three generations: 2'499 parameters

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \varphi)$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Grzadkowski, Iskrzynski, Misiak, Rosiek [1008.4884]

Dimension-6 SMEFT

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 - Three generations: 2'499 parameters
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X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
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$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^{\gamma j})^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^{\gamma m})^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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- At the level of SM

$$\mathcal{L}_\psi \dots U(3)^5 = U(3)_q \times U(3)_\ell \times U(3)_u \times U(3)_d \times U(3)_e$$

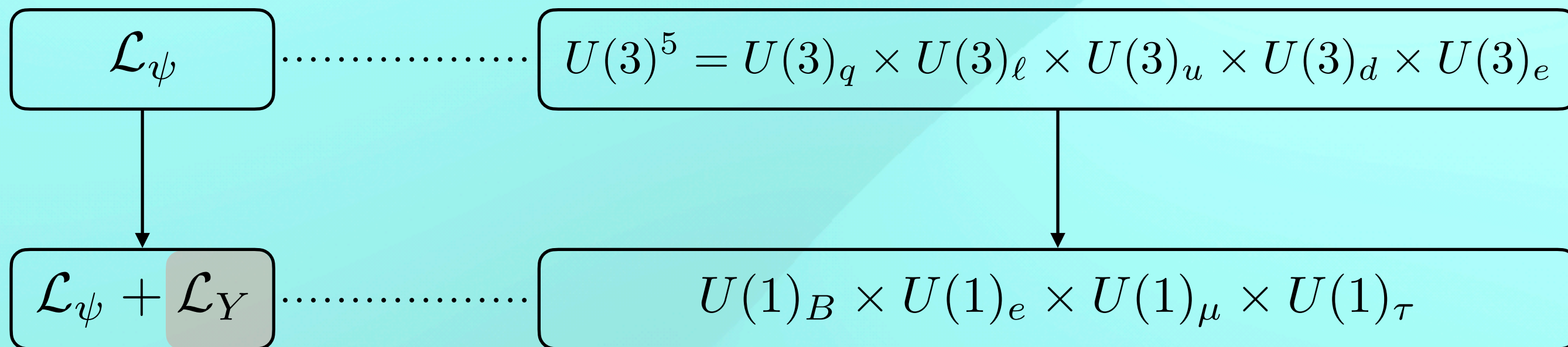
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Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

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Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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- Model-independent \implies large # of independent parameters
- Dimension-6 basis
 - Single generation: 59 parameters
 - Three generations: 2'499 parameters
- Proliferation originates from **flavor structure**
- At the level of SM



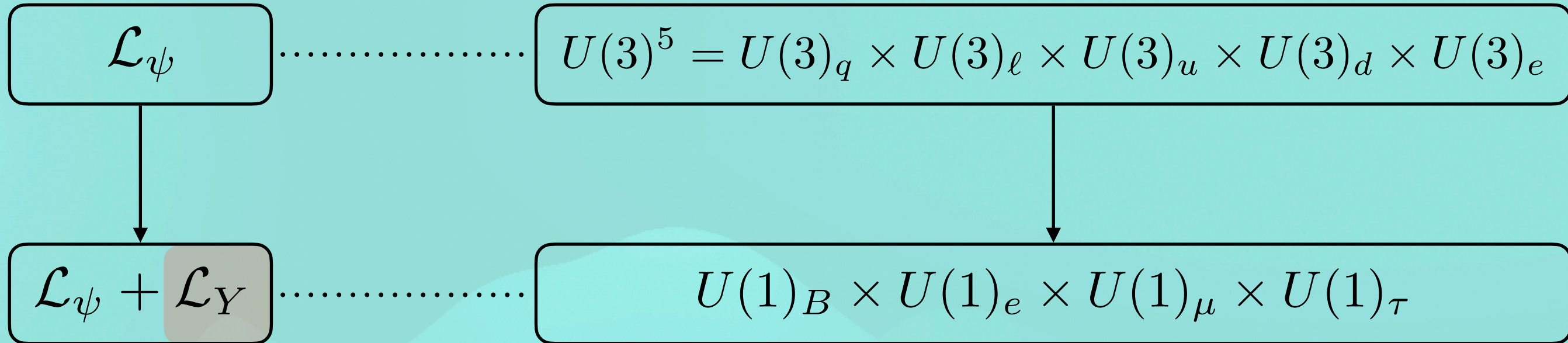
$$\mathcal{L}_Y = -\bar{q}_L^i Y_u^{ij} u_R^j \tilde{\Phi} - \bar{q}_L^i Y_d^{ij} d_R^j \Phi - \bar{\ell}_L^i Y_e^{ij} e_R^j \Phi + \text{h.c.}$$

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_\tau \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_\tau \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_\tau \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_\tau)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_\tau)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_\tau) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_\tau)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_\tau)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_\tau)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_\tau) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_\tau)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_\tau)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_\tau)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_\tau)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_\tau)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_\tau) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_\tau) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_\tau) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_\tau) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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$$\mathcal{L}_Y = -\bar{q}_L^i Y_u^{ij} u_R^j \tilde{\Phi} - \bar{q}_L^i Y_d^{ij} d_R^j \Phi - \bar{\ell}_L^i Y_e^{ij} e_R^j \Phi + \text{h.c.}$$

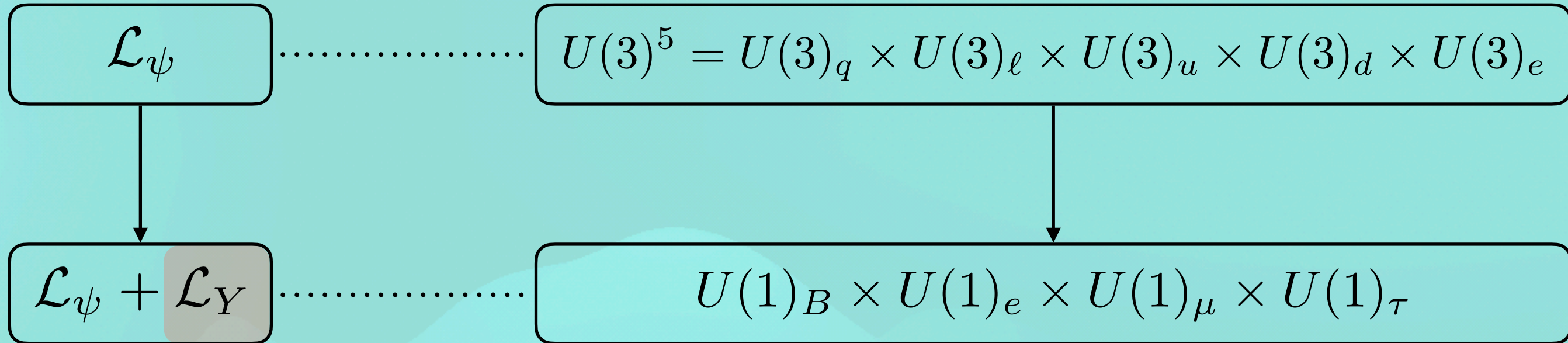
- Observational input: CKM alignment and mass hierarchies

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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$$\mathcal{L}_Y = -\bar{q}_L^i Y_u^{ij} u_R^j \tilde{\Phi} - \bar{q}_L^i Y_d^{ij} d_R^j \Phi - \bar{\ell}_L^i Y_e^{ij} e_R^j \Phi + \text{h.c.}$$

- Observational input: CKM alignment and mass hierarchies
- $\mathcal{O}(\text{TeV})$ NP shouldn't excessively violate flavor symmetries

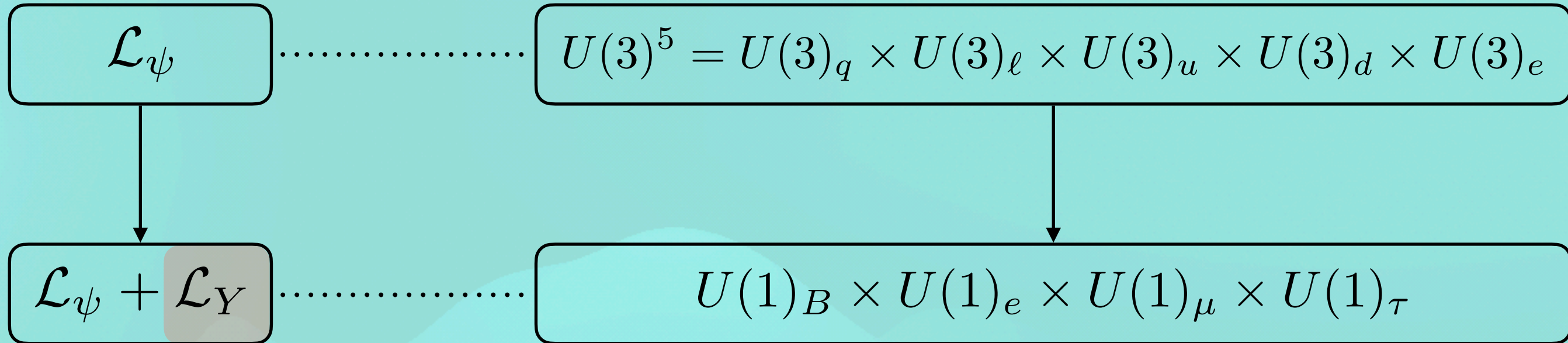
Physics Briefing Book [1910.11775]

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_\tau \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_\tau \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_\tau \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_\tau)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_\tau)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_\tau) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_\tau)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_\tau)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_\tau)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_\tau) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_\tau)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_\tau)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_\tau)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_\tau)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_\tau)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_\tau) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_\tau) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_\tau) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_\tau) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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$$\mathcal{L}_Y = -\bar{q}_L^i Y_u^{ij} u_R^j \tilde{\Phi} - \bar{q}_L^i Y_d^{ij} d_R^j \Phi - \bar{\ell}_L^i Y_e^{ij} e_R^j \Phi + \text{h.c.}$$

- Observational input: CKM alignment and mass hierarchies
- $\mathcal{O}(\text{TeV})$ NP shouldn't excessively violate flavor symmetries

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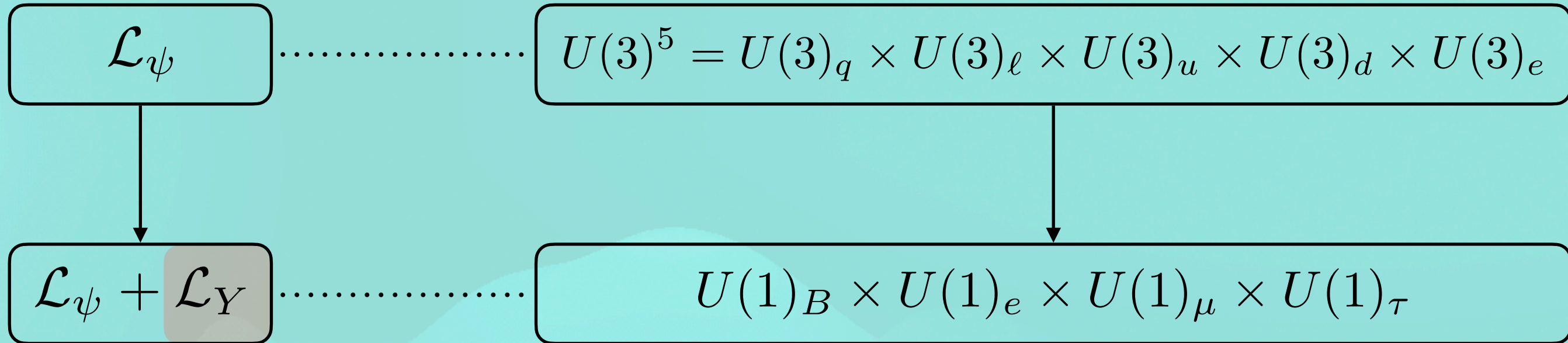
Approximate flavor symmetries

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_\tau \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_\tau \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_\tau \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_\tau)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_\tau)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_\tau) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_\tau)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_\tau)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_\tau)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_\tau) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_\tau)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_\tau)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_\tau)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_\tau)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_\tau)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^{\gamma j})^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_\tau) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_\tau) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^{\gamma m})^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_\tau) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_\tau) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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$$\mathcal{L}_Y = -\bar{q}_L^i Y_u^{ij} u_R^j \tilde{\Phi} - \bar{q}_L^i Y_d^{ij} d_R^j \Phi - \bar{\ell}_L^i Y_e^{ij} e_R^j \Phi + \text{h.c.}$$

- Observational input: CKM alignment and mass hierarchies
- $\mathcal{O}(\text{TeV})$ NP shouldn't excessively violate flavor symmetries

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Approximate flavor symmetries

- Starting point of our analysis

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_\tau \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_\tau \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_\tau \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_\tau)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_\tau)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_\tau) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_\tau)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_\tau)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_\tau) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_\tau)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_\tau) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_\tau)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_\tau)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_\tau) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_\tau)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_\tau)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_\tau)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_\tau)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_\tau)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_\tau)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_\tau)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating	
Q_{ledq}	$(\bar{l}_p^j e_\tau)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_\tau) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_\tau) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_\tau) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_\tau) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

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Flavor structure of the SMEFT

Flavor symmetries in SMEFT

- Analysis of the $U(3)^5$ subgroups

$$\mathcal{L}_\psi \dots U(3)^5 = U(3)_q \times U(3)_u \times U(3)_d \times U(3)_\ell \times U(3)_e$$

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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Flavor symmetries in SMEFT

- Analysis of the $U(3)^5$ subgroups

$$\mathcal{L}_\psi \dots U(3)^5 = U(3)_q \times U(3)_u \times U(3)_d \times U(3)_\ell \times U(3)_e$$

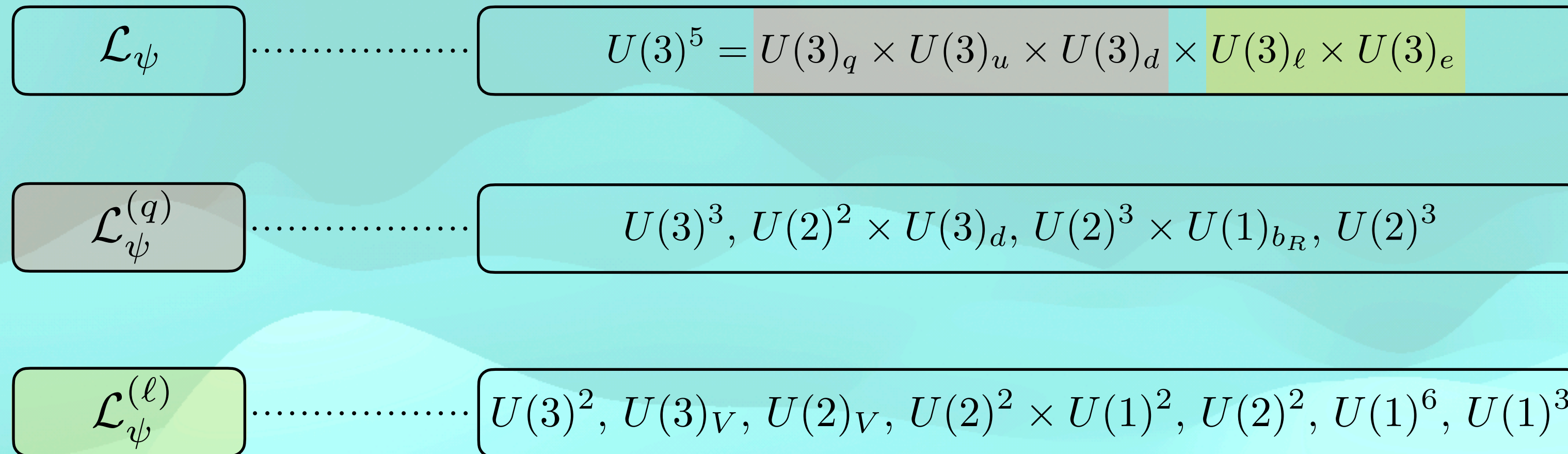
X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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Flavor symmetries in SMEFT

- Analysis of the $U(3)^5$ subgroups



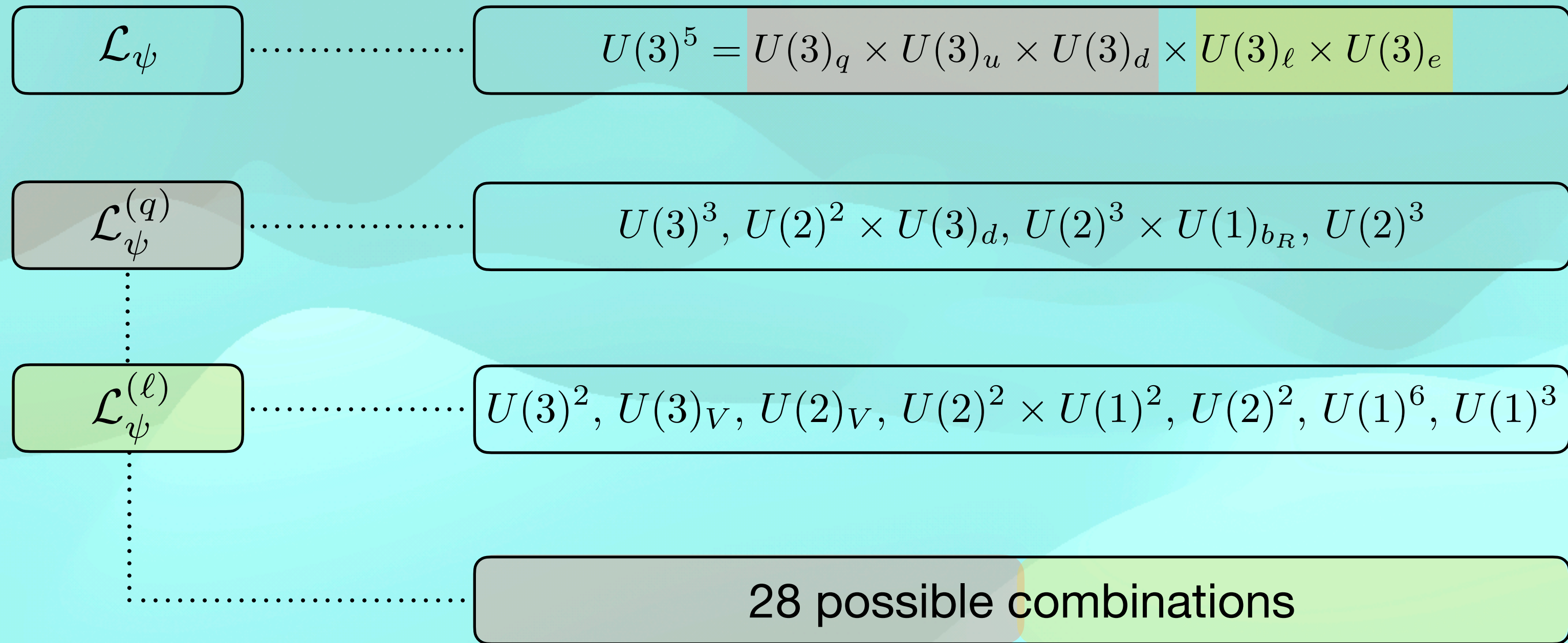
X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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Flavor symmetries in SMEFT

- Analysis of the $U(3)^5$ subgroups



Greljo, AP, Thomsen [2203.09561]

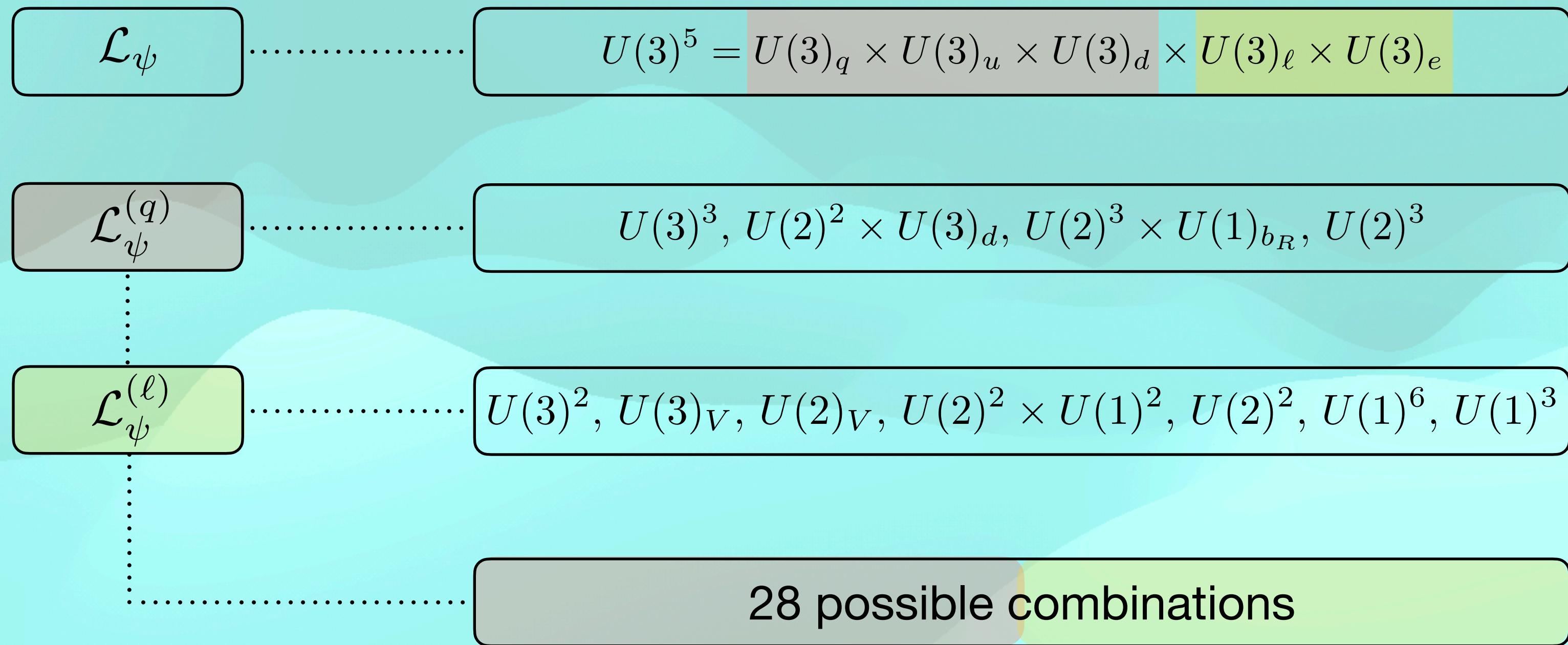
X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Grzadkowski, Iskrzynski, Misiak, Rosiek [1008.4884]

Flavor symmetries in SMEFT

- Analysis of the $U(3)^5$ subgroups



Greljo, AP, Thomsen [2203.09561]

- Extraction of flavor invariants of the SMEFT operators

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)

Flavor symmetry group

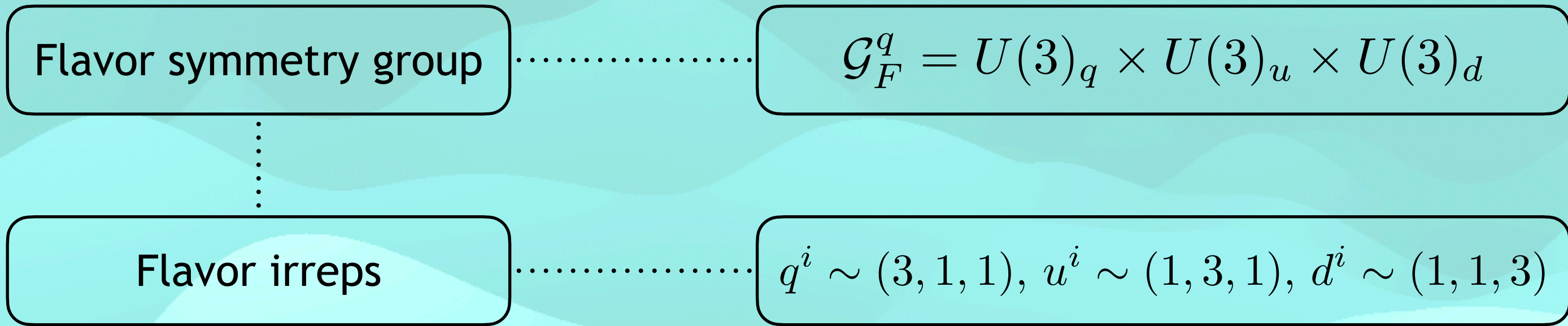
$$\mathcal{G}_F^q = U(3)_q \times U(3)_u \times U(3)_d$$

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)

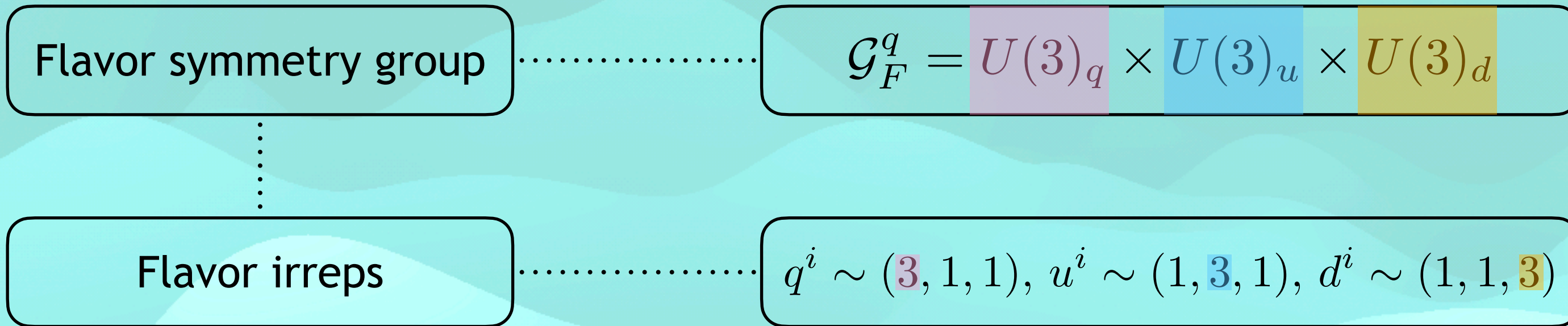


X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)



X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

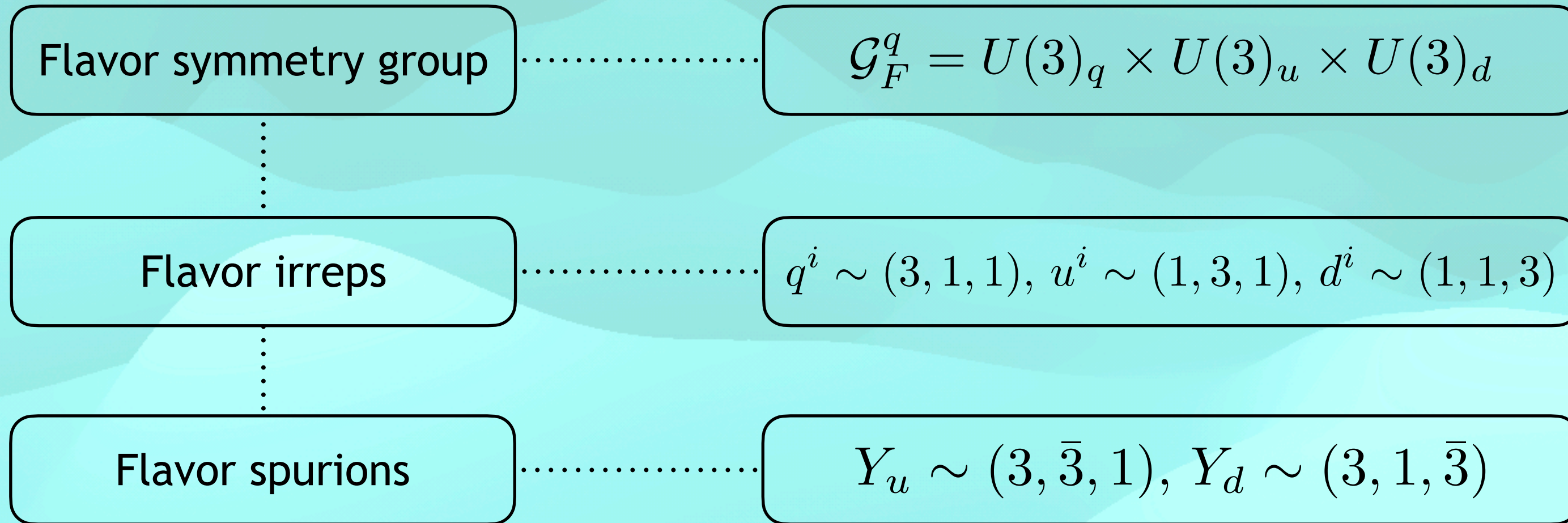
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

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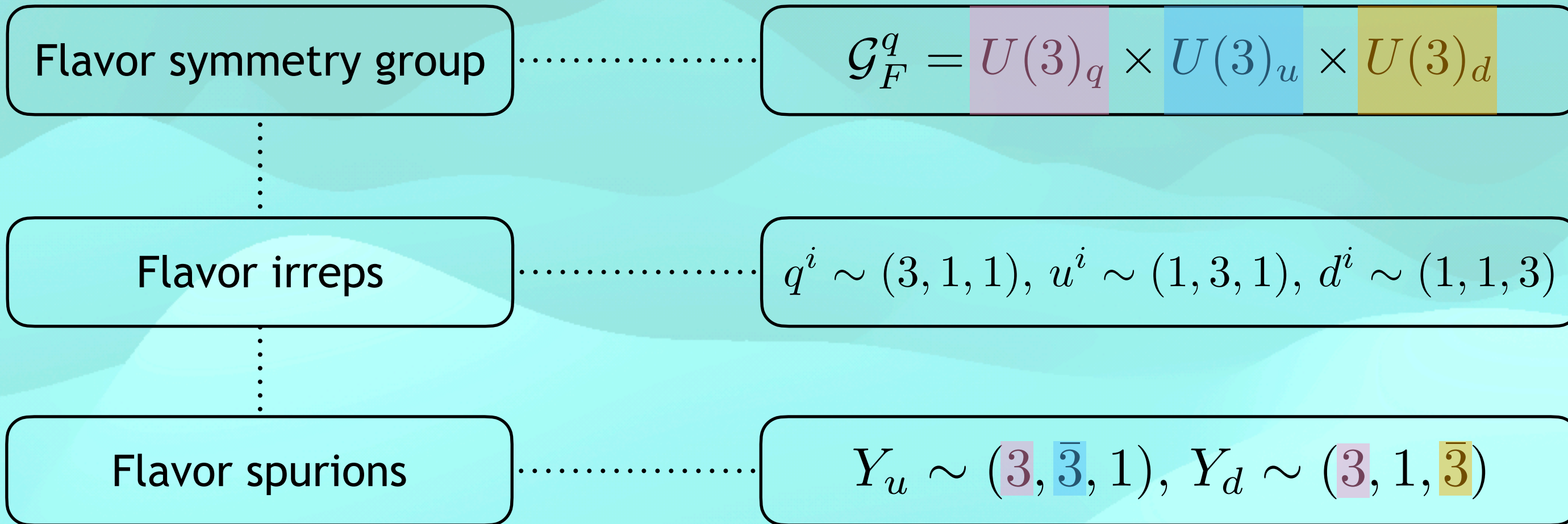


X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)

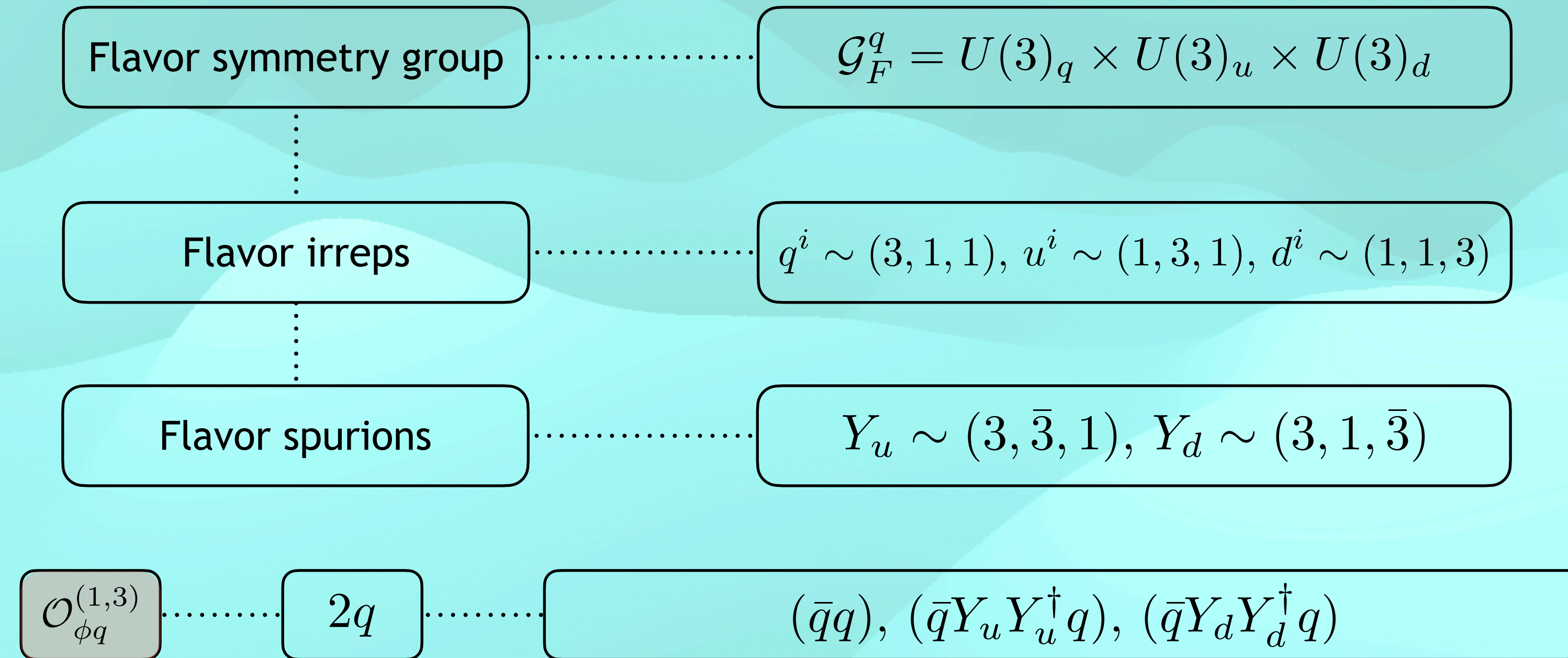


X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)

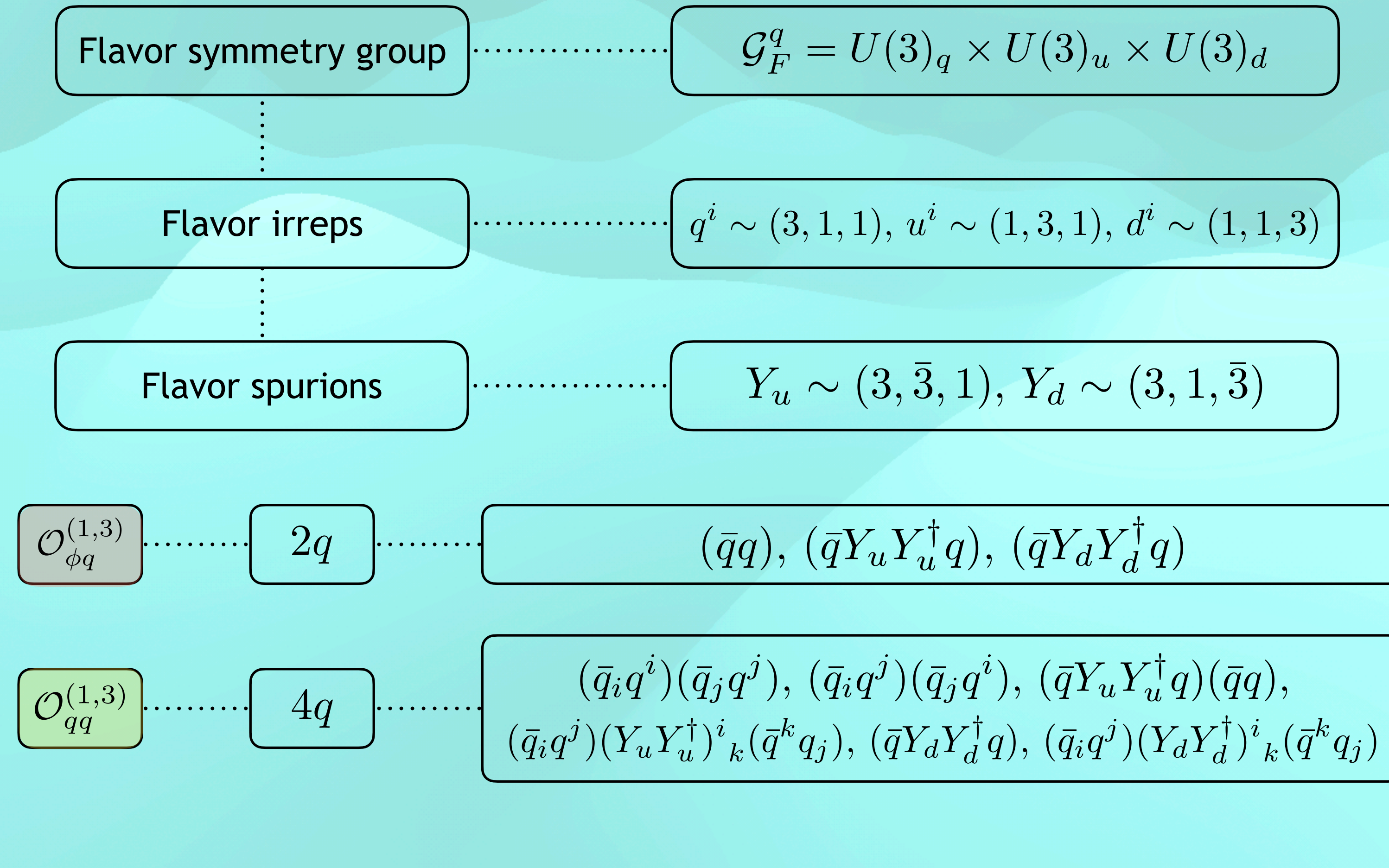


X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

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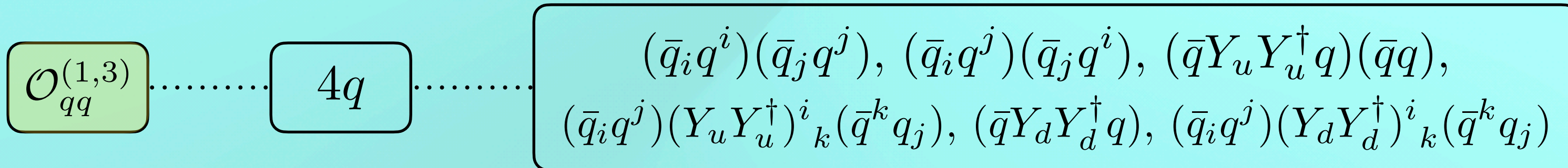
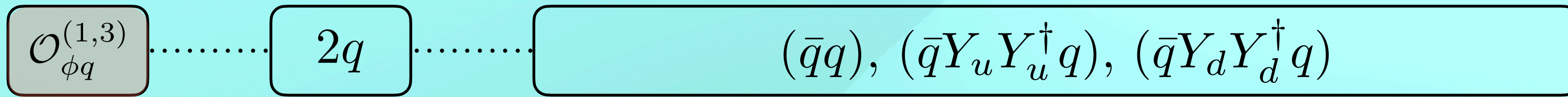
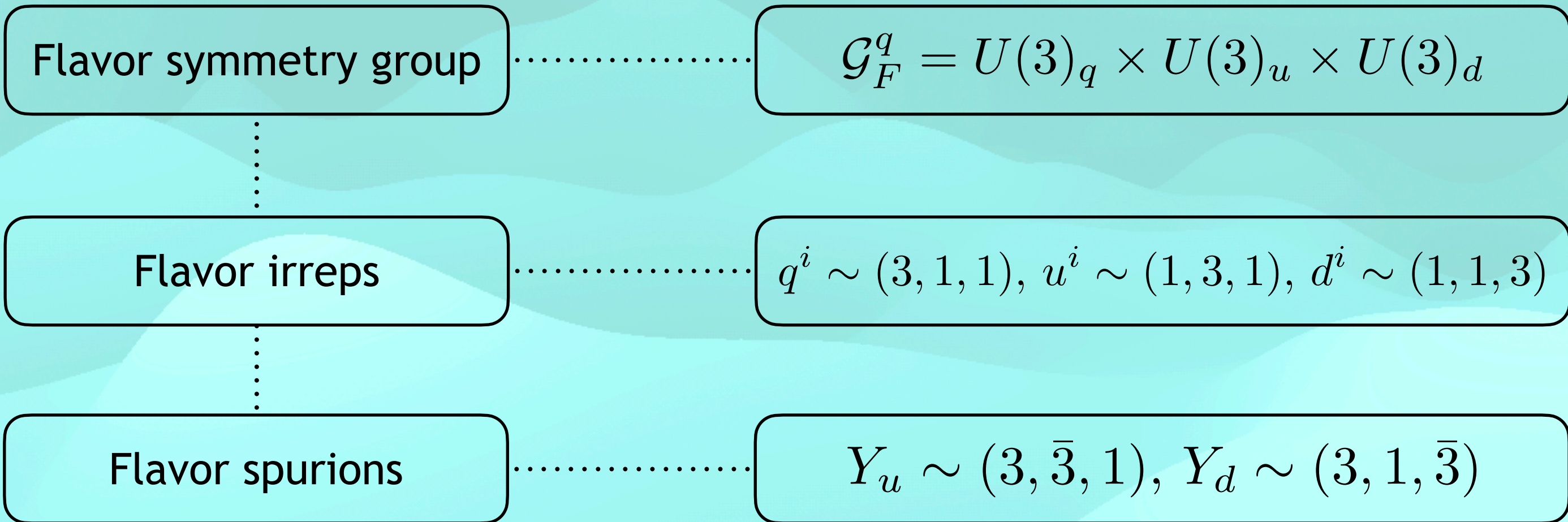


X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^i)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Example: $2q$ and $4q$ operators with $U(3)^3$

- Flavor invariants constructed at various orders in spurion expansion (flavor power counting)



- Similar procedure applied to all SMEFT operators

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^i)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Flavor parameter counting

- The number of independent parameters collected in a table

MFV _Q		O(1)	O(Y _u)	O(Y _u ²)	O(Y _d)	O(Y _d ²)	O(Y _u Y _d)	O(Y _u ² Y _d , Y _d ² Y _u)	O(Y _u ³ , Y _d ³)					
$\psi^2 H^3$	Q_{uH}	1	1					1	1					
	Q_{dH}				1	1		1	1					
$\psi^2 XH$	$Q_{u(G,W,B)}$	3	3					3	3					
	$Q_{d(G,W,B)}$				3	3		3	3					
$\psi^2 H^2 D$	$Q_{Hq}^{(1,3)}$	2		2										
	Q_{Hu}	1		1										
	Q_{Hd}	1				1								
	Q_{Hud}						1	1						
$(LL)(LL)$	$Q_{qq}^{(1,3)}$	4		4				4						
$(RR)(RR)$	Q_{uu}	2		2										
	Q_{dd}	2				2								
	$Q_{ud}^{(1,8)}$	2		2		2								
$(LL)(RR)$	$Q_{qu}^{(1,8)}$	2			6			2						
	$Q_{qd}^{(1,8)}$	2			2			6						
$(LR)(LR)$	$Q_{quqd}^{(1,8)}$						4	4						
Total		18	4	4	19	4	4	19	5	5	8	8	8	8

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B-violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Flavor parameter counting

- The number of independent parameters collected in a table

MFV _Q		O(1)	O(Y _u)	O(Y _u ²)	O(Y _d)	O(Y _d ²)	O(Y _u Y _d)	O(Y _u ² Y _d , Y _d ² Y _u)	O(Y _u ³ , Y _d ³)					
$\psi^2 H^3$	Q_{uH}		1	1					1	1				
	Q_{dH}						1	1	1	1				
$\psi^2 XH$	$Q_{u(G,W,B)}$		3	3					3	3				
	$Q_{d(G,W,B)}$						3	3	3	3				
$\psi^2 H^2 D$	$Q_{Hq}^{(1,3)}$	2			2									
	Q_{Hu}	1			1									
	Q_{Hd}	1						1						
	Q_{Hud}								1	1				
$(LL)(LL)$	$Q_{qq}^{(1,3)}$	4			4									
$(RR)(RR)$	Q_{uu}	2			2									
	Q_{dd}	2						2						
	$Q_{ud}^{(1,8)}$	2			2			2						
$(LL)(RR)$	$Q_{qu}^{(1,8)}$	2			6			2						
	$Q_{qd}^{(1,8)}$	2			2			6						
$(LR)(LR)$	$Q_{quqd}^{(1,8)}$							4	4					
Total		18	4	4	19	4	4	19	5	5	8	8	8	8

Dim-6 SMEFT operator class

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B-violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^{\gamma j})^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^{\gamma m})^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Flavor parameter counting

- The number of independent parameters collected in a table

Orders in spurion expansion

MFV _Q		O(1)	O(Y _u)	O(Y _u ²)	O(Y _d)	O(Y _d ²)	O(Y _u Y _d)	O(Y _u ² Y _d , Y _d ² Y _u)	O(Y _u ³ , Y _d ³)					
$\psi^2 H^3$	Q_{uH}		1	1					1	1				
	Q_{dH}				1	1			1	1				
$\psi^2 XH$	$Q_{u(G,W,B)}$		3	3					3	3				
	$Q_{d(G,W,B)}$				3	3			3	3				
$\psi^2 H^2 D$	$Q_{Hq}^{(1,3)}$	2		2										
	Q_{Hu}	1		1										
	Q_{Hd}	1				1								
	Q_{Hud}						1	1						
(LL)(LL)	$Q_{qq}^{(1,3)}$	4		4										
(RR)(RR)	Q_{uu}	2		2										
	Q_{dd}	2				2								
	$Q_{ud}^{(1,8)}$	2		2		2								
(LL)(RR)	$Q_{qu}^{(1,8)}$	2		6		2								
	$Q_{qd}^{(1,8)}$	2		2		6								
(LR)(LR)	$Q_{quqd}^{(1,8)}$						4	4						
Total		18	4	4	19	4	4	19	5	5	8	8	8	8

Dim-6 SMEFT operator class

X ³		φ ⁶ and φ ⁴ D ²		ψ ² φ ³	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

X ² φ ²		ψ ² Xφ		ψ ² φ ² D	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

(LL)(LL)		(RR)(RR)		(LL)(RR)	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

(LR)(RL) and (LR)(LR)		B-violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t^j)$	Q_{quu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t^j)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t^j)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t^j)$		

Flavor parameter counting

- The number of independent parameters collected in a table

Orders in spurion expansion

MFV _Q		O(1)	O(Y _u)	O(Y _u ²)	O(Y _d)	O(Y _d ²)	O(Y _u Y _d)	O(Y _u ² Y _d , Y _d ² Y _u)	O(Y _u ³ , Y _d ³)					
$\psi^2 H^3$	Q_{uH}		1	1					1	1				
	Q_{dH}				1	1			1	1				
$\psi^2 XH$	$Q_{u(G,W,B)}$		3	3					3	3				
	$Q_{d(G,W,B)}$				3	3			3	3				
$\psi^2 H^2 D$	$Q_{Hq}^{(1,3)}$	2		2										
	Q_{Hu}	1		1										
	Q_{Hd}	1				1								
	Q_{Hud}						1	1						
$(LL)(LL)$	$Q_{qq}^{(1,3)}$	4		4										
$(RR)(RR)$	Q_{uu}	2		2										
	Q_{dd}	2				2								
	$Q_{ud}^{(1,8)}$	2		2		2								
$(LL)(RR)$	$Q_{qu}^{(1,8)}$	2		6		2								
	$Q_{qd}^{(1,8)}$	2		2		6								
$(LR)(LR)$	$Q_{quqd}^{(1,8)}$						4	4						
Total		18	4	4	19	4	4	19	5	5	8	8	8	8

Dim-6 SMEFT operator class

Total # of independent parameters at given order in spurion expansion

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B-violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t^j)$	Q_{quu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t^j)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t^j)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t^j)$		

Flavor parameter counting

- Overview of the # of $\mathcal{O}(1)$ parameters

Greljo, AP, Thomsen [2203.09561]

SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
		MFV _L		U(3) _V		U(2) ² × U(1) ²		U(2) ²		U(2) _V		U(1) ⁶		U(1) ³		No symm.	
Quark sector	MFV _Q	41	6	45	9	59	6	62	9	67	13	81	6	93	18	207	132
	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Flavor parameter counting

- Overview of the # of $\mathcal{O}(1)$ parameters

Greljo, AP, Thomsen [2203.09561]

SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
		MFV _L		U(3) _V		U(2) ² × U(1) ²		U(2) ²		U(2) _V		U(1) ⁶		U(1) ³		No symm.	
Quark sector	MFV _Q	41	6	45	9	59	6	62	9	67	13	81	6	93	18	207	132
	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

47 parameters

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

Flavor parameter counting

- Overview of the # of $\mathcal{O}(1)$ parameters

Greljo, AP, Thomsen [2203.09561]

SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
		MFV _L		U(3) _V		U(2) ² × U(1) ²		U(2) ²		U(2) _V		U(1) ⁶		U(1) ³		No symm.	
Quark sector	MFV _Q	41	6	45	9	59	6	62	9	67	13	81	6	93	18	207	132
	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

47 parameters

147 parameters

Faroughy, Isidori, Wilsch, Yamamoto [2005.05366]

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Flavor parameter counting

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SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
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	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

47 parameters

147 parameters

2'499 parameters

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

Flavor parameter counting

- Overview of the # of $\mathcal{O}(1)$ parameters

Greljo, AP, Thomsen [2203.09561]

SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
		MFV _L		U(3) _V		U(2) ² × U(1) ²		U(2) ²		U(2) _V		U(1) ⁶		U(1) ³		No symm.	
Quark sector	MFV _Q	41	6	45	9	59	6	62	9	67	13	81	6	93	18	207	132
	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

47 parameters

147 parameters

2'499 parameters

- Can SMEFT landscape tell us something about NP?

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

Flavor parameter counting

- Overview of the # of $\mathcal{O}(1)$ parameters

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SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
		MFV _L		U(3) _V		U(2) ² × U(1) ²		U(2) ²		U(2) _V		U(1) ⁶		U(1) ³		No symm.	
Quark sector	MFV _Q	41	6	45	9	59	6	62	9	67	13	81	6	93	18	207	132
	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

47 parameters

147 parameters

2'499 parameters

- Can SMEFT landscape tell us something about NP?
- Interplay of flavor symmetries and NP mediators

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				

$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$

$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating	
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{d}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{ijk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{d}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$		

Leading SMEFT directions

$U(3)^5$ SMEFT basis

- We focus on the lowest entry in the $\mathcal{O}(1)$ table

Greljo, AP, Thomsen [2203.09561]

SMEFT $\mathcal{O}(1)$ terms (dim-6, $\Delta B = 0$)		Lepton sector															
		MFV _L		U(3) _V		U(2) ² × U(1) ²		U(2) ²		U(2) _V		U(1) ⁶		U(1) ³		No symm.	
Quark sector	MFV _Q	41	6	45	9	59	6	62	9	67	13	81	6	93	18	207	132
	U(2) ² × U(3) _d	72	10	78	15	95	10	100	15	107	21	122	10	140	28	281	169
	U(2) ³ × U(1) _{d3}	86	10	92	15	111	10	116	12	123	21	140	10	158	28	305	175
	U(2) ³	93	17	100	23	118	17	124	23	132	30	147	17	168	38	321	191
	No symmetry	703	570	734	600	756	591	786	621	818	652	813	612	906	705	1350	1149

47 parameters

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- Construction of the $U(3)^5$ -symmetric SMEFT basis at $\mathcal{O}(1)$

Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i\gamma^\mu\ell^j)(\bar{\ell}_j\gamma_\mu\ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^j)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^j)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^j)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^j)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i\gamma^\mu e^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i\gamma^\mu T^A u^i)(\bar{d}_j\gamma_\mu T^A d^j)$
	\mathcal{O}_{ed}	$(\bar{e}_i\gamma^\mu e^i)(\bar{d}_j\gamma_\mu d^j)$		
$(\bar{L}L)(\bar{R}R)$	$\mathcal{O}_{\ell e}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{u}_j\gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i\gamma^\mu q^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{u}_j\gamma_\mu T^A u^j)$
	$\mathcal{O}_{\ell u}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{d}_j\gamma_\mu d^j)$
	$\mathcal{O}_{\ell d}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{d}_j\gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{u}_i\gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{q}_i\gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{d}_i\gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{q}_i\gamma^\mu\sigma^a q^i)$		
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc}W_\mu^{a\nu}W_\nu^b\rho W_\rho^c\mu$	\mathcal{O}_G	$f_{ABC}G_\mu^{A\nu}G_\nu^B\rho G_\rho^C\mu$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc}\tilde{W}_\mu^{a\nu}W_\nu^b\rho W_\rho^c\mu$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^B\rho G_\rho^C\mu$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger\phi)^3$		
ϕ^4D^2	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu\phi)[(D^\mu\phi)^\dagger\phi]$
$X^2\phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)B_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^a\phi)W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi\tilde{B}}$	$(\phi^\dagger\phi)\tilde{B}_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi\tilde{W}B}$	$(\phi^\dagger\sigma^a\phi)\tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger\phi)G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi\tilde{W}}$	$(\phi^\dagger\phi)\tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi\tilde{G}}$	$(\phi^\dagger\phi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
$\psi^2\phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger\phi)(\bar{\ell}_{i\ell}^j\phi e^{je})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi u^{ju})$
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi d^{jd})$		
$\psi^2X\phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\tilde{\phi}B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\sigma^a\tilde{\phi}W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A u^{ju})\tilde{\phi}G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A d^{jd})\phi G_{\mu\nu}^A$

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47 parameters

- Construction of the $U(3)^5$ -symmetric SMEFT basis at $\mathcal{O}(1)$
- Operators can be generated at tree-level in a renormalizable UV completion

Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i\gamma^\mu\ell^j)(\bar{\ell}_j\gamma_\mu\ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^j)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^j)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^j)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^j)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
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$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
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	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
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- Construction of the $U(3)^5$ -symmetric SMEFT basis at $\mathcal{O}(1)$
- Operators can be generated at tree-level in a renormalizable UV completion
- What are all tree-level UV completions that match to these operators?

Greljo, AP [2305.08898]

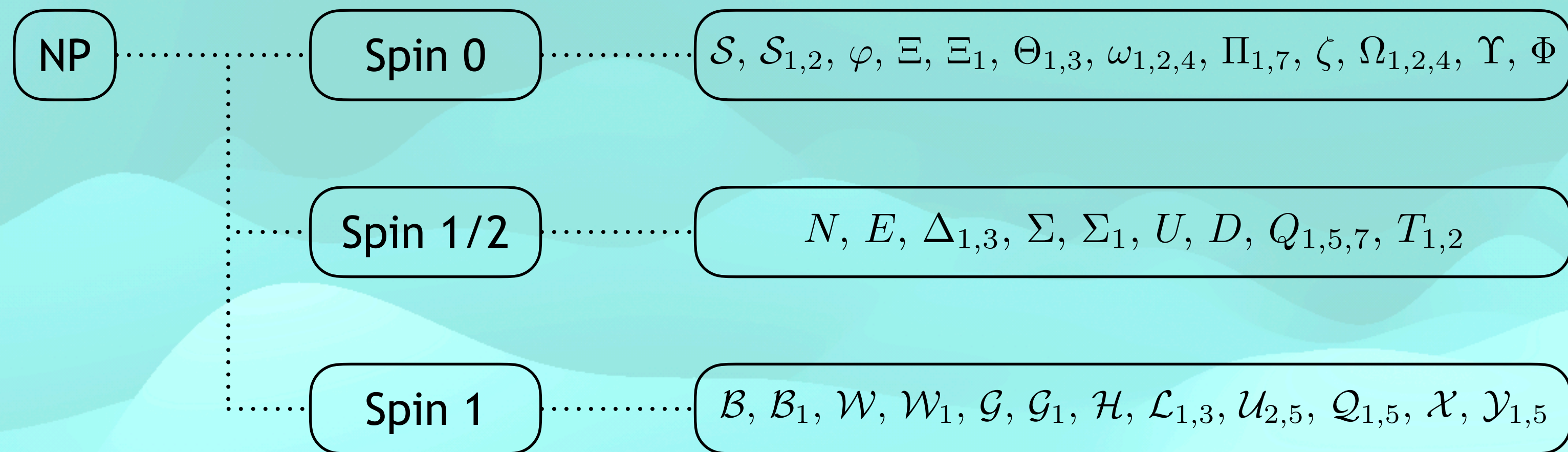
Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
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	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^j)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^j)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^j)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^j)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i\gamma^\mu e^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i\gamma^\mu T^A u^i)(\bar{d}_j\gamma_\mu T^A d^j)$
	\mathcal{O}_{ed}	$(\bar{e}_i\gamma^\mu e^i)(\bar{d}_j\gamma_\mu d^j)$		
$(\bar{L}L)(\bar{R}R)$	$\mathcal{O}_{\ell e}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{u}_j\gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i\gamma^\mu q^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{u}_j\gamma_\mu T^A u^j)$
	$\mathcal{O}_{\ell u}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{d}_j\gamma_\mu d^j)$
	$\mathcal{O}_{\ell d}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{d}_j\gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{u}_i\gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{q}_i\gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{d}_i\gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{q}_i\gamma^\mu\sigma^a q^i)$		

Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc}W_\mu^{a\nu}W_\nu^b\rho W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC}G_\mu^{A\nu}G_\nu^B\rho G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc}\tilde{W}_\mu^{a\nu}W_\nu^b\rho W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^B\rho G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger\phi)^3$		
ϕ^4D^2	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu\phi)[(D^\mu\phi)^\dagger\phi]$
$X^2\phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)B_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^a\phi)W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi\tilde{B}}$	$(\phi^\dagger\phi)\tilde{B}_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi\tilde{W}B}$	$(\phi^\dagger\sigma^a\phi)\tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger\phi)G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi\tilde{W}}$	$(\phi^\dagger\phi)\tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi\tilde{G}}$	$(\phi^\dagger\phi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu}$

Class	Label	Operator	Label	Operator
$\psi^2\phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger\phi)(\bar{\ell}_{i\ell}^j\phi e^{je})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi u^{ju})$
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi d^{jd})$		
$\psi^2X\phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\phi B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A u^{ju})\phi G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A d^{jd})\phi G_{\mu\nu}^A$

UV completions

- NP fields as SM gauge irreps

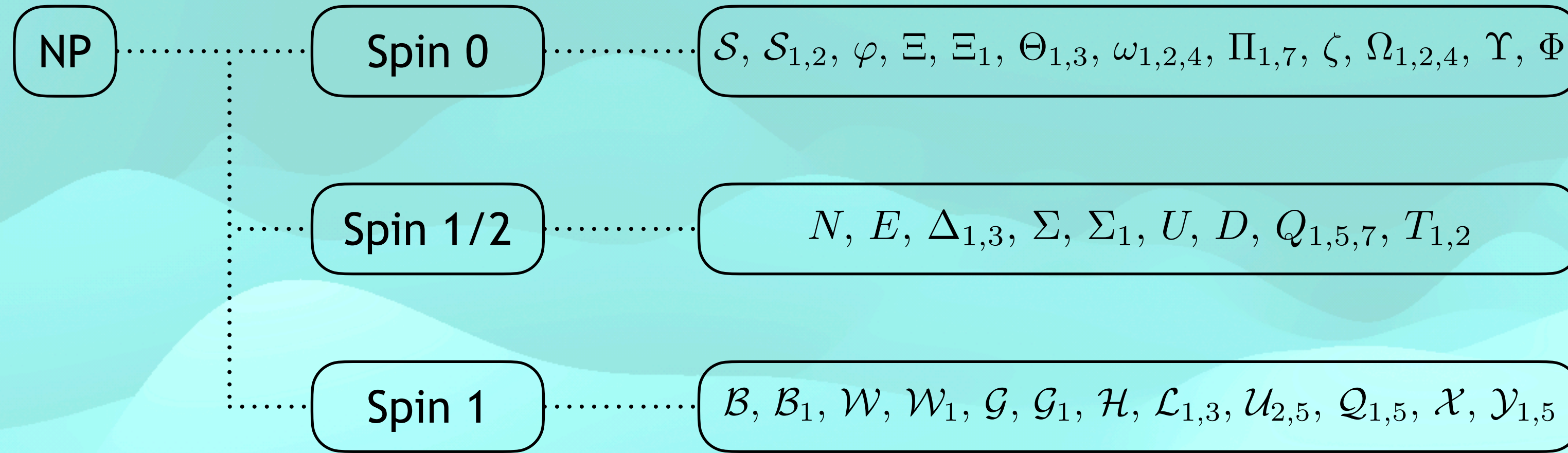


De Blas, Criado, Perez-Victoria, Santiago [1711.10391]

Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i\gamma^\mu e^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i\gamma^\mu T^A u^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{u}_j\gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i\gamma^\mu q^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{u}_j\gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{d}_j\gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{u}_i\gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{q}_i\gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{d}_i\gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{q}_i\gamma^\mu\sigma^a q^i)$		
Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc}W_\mu^{a\nu}W_\nu^b{}^\rho W_\rho^c{}^\mu$	\mathcal{O}_G	$f_{ABC}G_\mu^{A\nu}G_\nu^B{}^\rho G_\rho^C{}^\mu$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc}\tilde{W}_\mu^{a\nu}W_\nu^b{}^\rho W_\rho^c{}^\mu$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^B{}^\rho G_\rho^C{}^\mu$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger\phi)^3$		
ϕ^4D^2	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu\phi)[(D^\mu\phi)^\dagger\phi]$
$X^2\phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)B_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^a\phi)W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi\tilde{B}}$	$(\phi^\dagger\phi)\tilde{B}_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi\tilde{W}B}$	$(\phi^\dagger\sigma^a\phi)\tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger\phi)G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi\tilde{W}}$	$(\phi^\dagger\phi)\tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi\tilde{G}}$	$(\phi^\dagger\phi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Class	Label	Operator	Label	Operator
$\psi^2\phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger\phi)(\bar{\ell}_{i\ell}^j\phi e^{je})$		
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi d^{jd})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi u^{ju})$
$\psi^2X\phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\tilde{\phi}B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\sigma^a\tilde{\phi}W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A u^{ju})\tilde{\phi}G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A d^{jd})\phi G_{\mu\nu}^A$

UV completions

- NP fields as SM gauge irreps



De Blas, Criado, Perez-Victoria, Santiago [1711.10391]

- The interaction Lagrangians are examined in the presence of $U(3)^5$ flavor symmetry

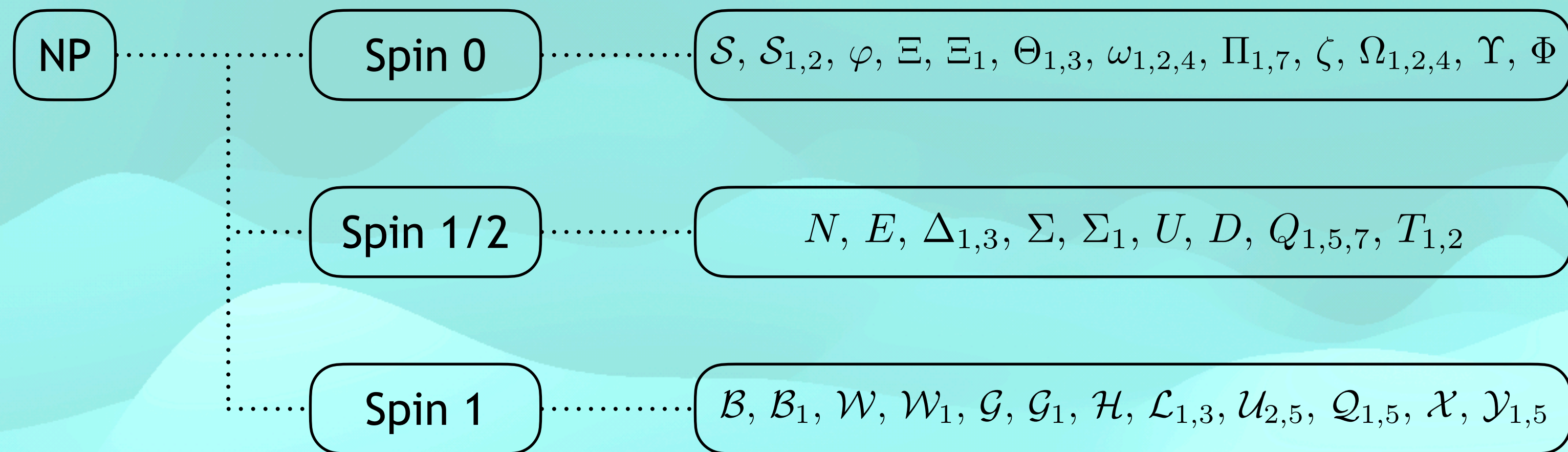
Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i\gamma^\mu\ell^j)(\bar{\ell}_j\gamma_\mu\ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^j)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^j)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^j)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^j)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i\gamma^\mu e^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i\gamma^\mu T^A u^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{u}_j\gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i\gamma^\mu q^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{u}_j\gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{d}_j\gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{u}_i\gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{q}_i\gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{d}_i\gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{q}_i\gamma^\mu\sigma^a q^i)$		

Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc}W_\mu^{a\nu}W_\nu^b\rho W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC}G_\mu^{A\nu}G_\nu^B\rho G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc}\tilde{W}_\mu^{a\nu}W_\nu^b\rho W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^B\rho G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger\phi)^3$		
ϕ^4D^2	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu\phi)[(D^\mu\phi)^\dagger\phi]$
$X^2\phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)B_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^a\phi)W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi\tilde{B}}$	$(\phi^\dagger\phi)\tilde{B}_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi\tilde{W}B}$	$(\phi^\dagger\sigma^a\phi)\tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger\phi)G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi\tilde{W}}$	$(\phi^\dagger\phi)\tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi\tilde{G}}$	$(\phi^\dagger\phi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu}$

Class	Label	Operator	Label	Operator
$\psi^2\phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger\phi)(\bar{\ell}_{i\ell}^j\phi e^{je})$		
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi d^{jd})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi u^{ju})$
$\psi^2X\phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\tilde{\phi}B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\sigma^a\tilde{\phi}W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A u^{ju})\tilde{\phi}G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A d^{jd})\phi G_{\mu\nu}^A$

UV completions

- NP fields as SM gauge irreps

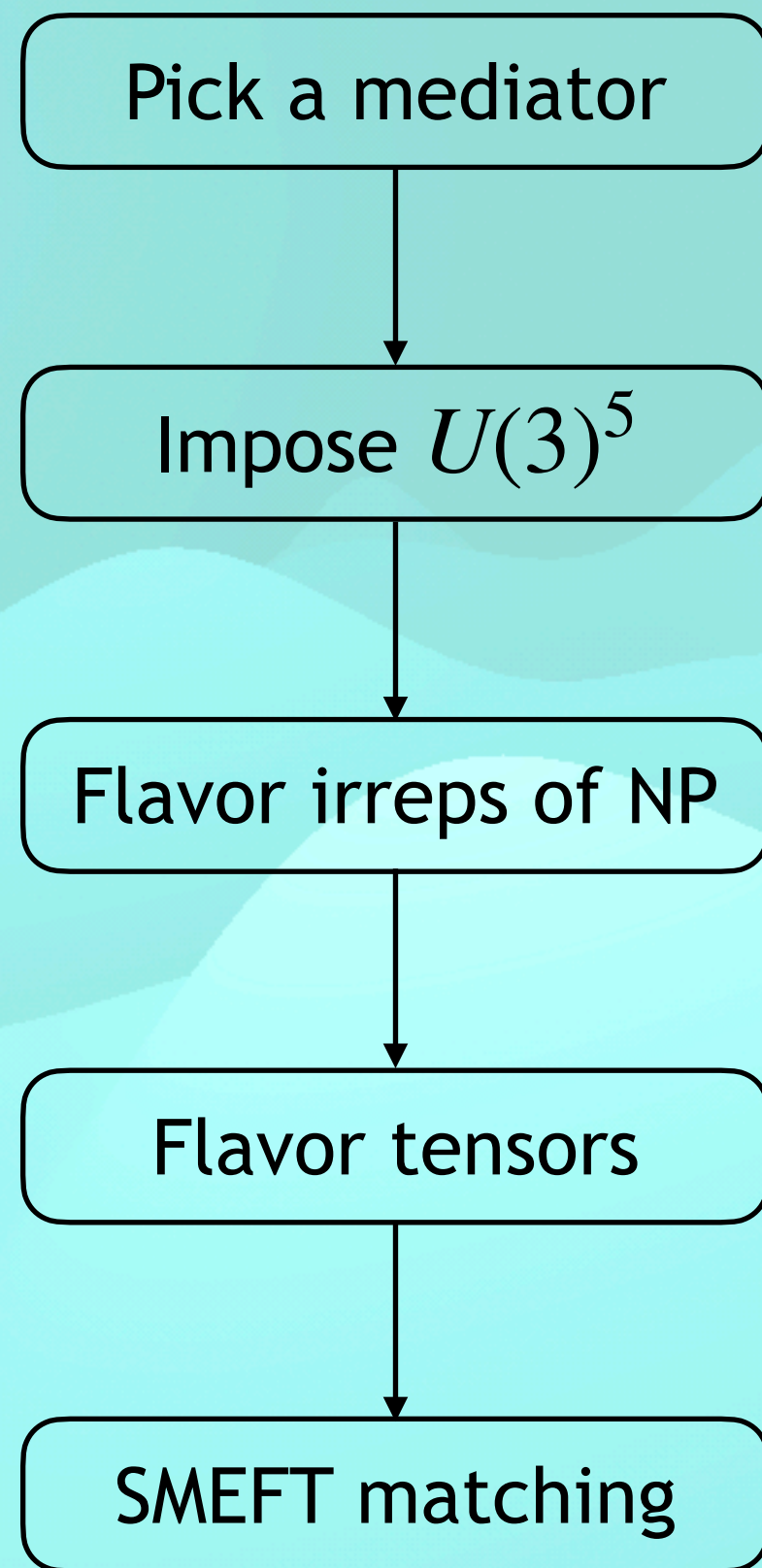


De Blas, Criado, Perez-Victoria, Santiago [1711.10391]

- The interaction Lagrangians are examined in the presence of $U(3)^5$ flavor symmetry
- SMEFT matching relations are obtained

Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i\gamma^\mu e^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i\gamma^\mu T^A u^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{u}_j\gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i\gamma^\mu q^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{u}_j\gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{d}_j\gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{u}_i\gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{q}_i\gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{d}_i\gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{q}_i\gamma^\mu\sigma^a q^i)$		
Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc}W_\mu^{a\nu}W_\nu^b\rho W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC}G_\mu^{A\nu}G_\nu^B\rho G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc}\tilde{W}_\mu^{a\nu}W_\nu^b\rho W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^B\rho G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger\phi)^3$		
ϕ^4D^2	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu\phi)[(D^\mu\phi)^\dagger\phi]$
$X^2\phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)B_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^a\phi)W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi\tilde{B}}$	$(\phi^\dagger\phi)\tilde{B}_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi\tilde{W}B}$	$(\phi^\dagger\sigma^a\phi)\tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger\phi)G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi\tilde{W}}$	$(\phi^\dagger\phi)\tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi\tilde{G}}$	$(\phi^\dagger\phi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Class	Label	Operator	Label	Operator
$\psi^2\phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger\phi)(\bar{\ell}_{i\ell}^j\phi e^{je})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi u^{ju})$
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi d^{jd})$		
$\psi^2X\phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\tilde{\phi}B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\sigma^a\tilde{\phi}W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A u^{ju})\tilde{\phi}G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A d^{jd})\phi G_{\mu\nu}^A$

Procedure outline



Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{\ell}_j\gamma_\mu\ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{q}_j\gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i\gamma^\mu\ell^j)(\bar{\ell}_j\gamma_\mu\ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{q}_j\gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i\gamma^\mu\sigma^a q^i)(\bar{q}_j\gamma_\mu\sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i\gamma^\mu q^j)(\bar{q}_j\gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i\gamma^\mu\sigma^a q^j)(\bar{q}_j\gamma_\mu\sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i\gamma^\mu e^i)(\bar{e}_j\gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i\gamma^\mu d^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i\gamma^\mu u^i)(\bar{u}_j\gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i\gamma^\mu d^j)(\bar{d}_j\gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i\gamma^\mu u^j)(\bar{u}_j\gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i\gamma^\mu u^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i\gamma^\mu e^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i\gamma^\mu T^A u^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{u}_j\gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i\gamma^\mu q^i)(\bar{e}_j\gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{u}_j\gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{u}_j\gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i\gamma^\mu q^i)(\bar{d}_j\gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i\gamma^\mu\ell^i)(\bar{d}_j\gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i\gamma^\mu T^A q^i)(\bar{d}_j\gamma_\mu T^A d^j)$
$\psi^2\phi^2D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{\ell}_i\gamma^\mu\ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{e}_i\gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{\ell}_i\gamma^\mu\sigma^a\ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{u}_i\gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{q}_i\gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu\phi)(\bar{d}_i\gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i\overleftrightarrow{D}_\mu^a\phi)(\bar{q}_i\gamma^\mu\sigma^a q^i)$		
Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc}W_\mu^{a\nu}W_\nu^{b\rho}W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC}G_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc}\tilde{W}_\mu^{a\nu}W_\nu^{b\rho}W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger\phi)^3$		
ϕ^4D^2	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger\phi)\Box(\phi^\dagger\phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu\phi)[(D^\mu\phi)^\dagger\phi]$
$X^2\phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger\phi)B_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger\sigma^a\phi)W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi\tilde{B}}$	$(\phi^\dagger\phi)\tilde{B}_{\mu\nu}B^{\mu\nu}$	$\mathcal{O}_{\phi\tilde{W}B}$	$(\phi^\dagger\sigma^a\phi)\tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger\phi)W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger\phi)G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi\tilde{W}}$	$(\phi^\dagger\phi)\tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi\tilde{G}}$	$(\phi^\dagger\phi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Class	Label	Operator	Label	Operator
$\psi^2\phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger\phi)(\bar{\ell}_{i\ell}^j\phi e^{je})$		
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi d^{jd})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger\phi)(\bar{q}_{iq}^j\phi u^{ju})$
$\psi^2X\phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j\sigma^{\mu\nu}e^{je})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\tilde{\phi}B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}u^{ju})\sigma^a\tilde{\phi}W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}d^{jd})\sigma^a\phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A u^{ju})\tilde{\phi}G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j\sigma^{\mu\nu}T^A d^{jd})\phi G_{\mu\nu}^A$

Procedure outline

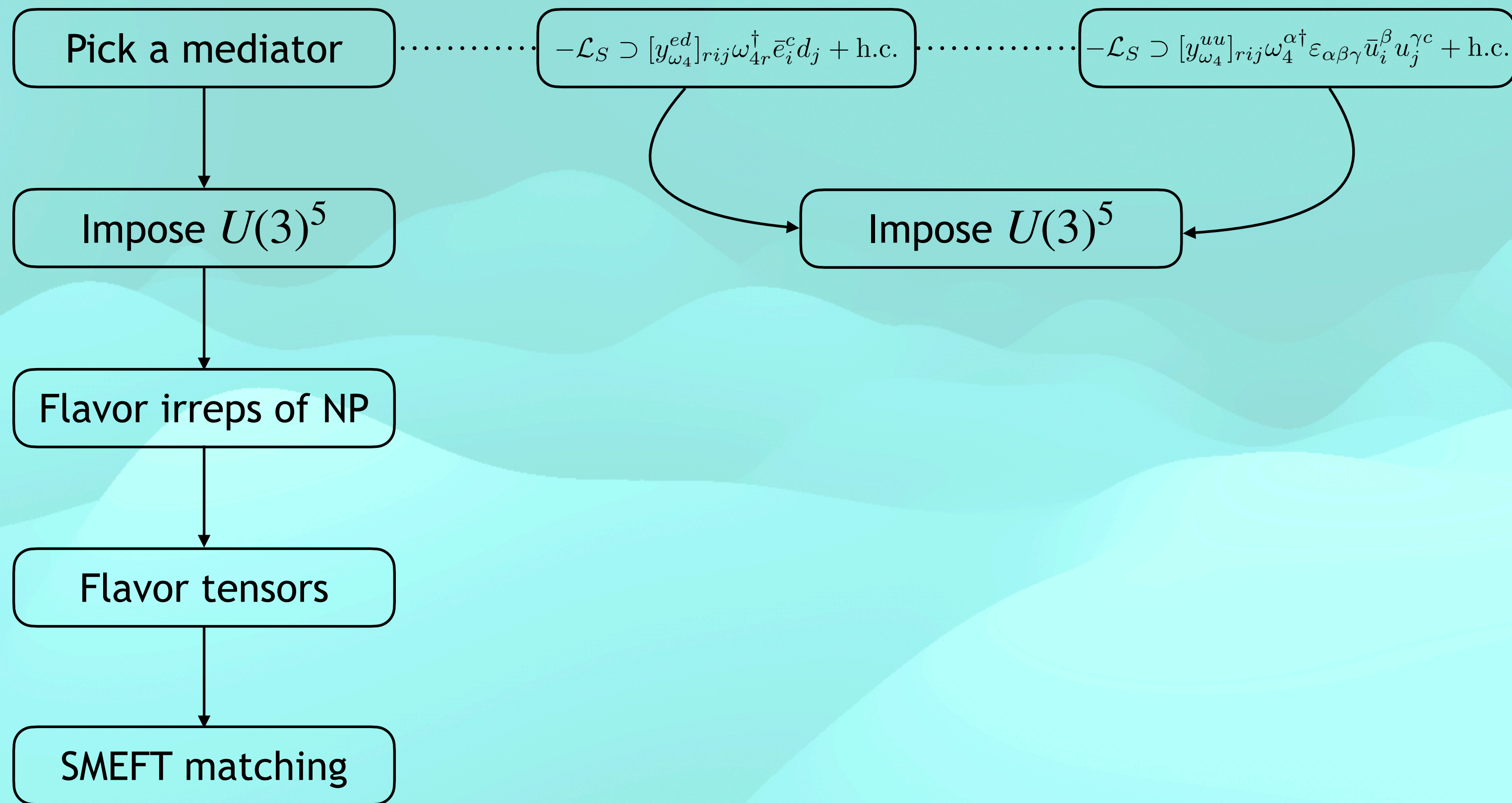
$$\omega_4 \sim (3, 1)_{-4/3}$$



Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{q}_j \gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i \gamma^\mu q^j)(\bar{q}_j \gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i \gamma^\mu \sigma^a q^j)(\bar{q}_j \gamma_\mu \sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i \gamma^\mu e^i)(\bar{e}_j \gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i \gamma^\mu d^j)(\bar{d}_j \gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i \gamma^\mu u^j)(\bar{u}_j \gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i \gamma^\mu u^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i \gamma^\mu e^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i \gamma^\mu T^A u^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{u}_j \gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i \gamma^\mu q^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{u}_j \gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{d}_j \gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$\psi^2 \phi^2 D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{\ell}_i \gamma^\mu \ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{e}_i \gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{u}_i \gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{q}_i \gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{d}_i \gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_i \gamma^\mu \sigma^a q^i)$		
Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc} W_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc} \tilde{W}_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger \phi)^3$		
$\phi^4 D^2$	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger \phi)\Box(\phi^\dagger \phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu \phi)[(D^\mu \phi)^\dagger \phi]$
$X^2 \phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger \phi) B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger \sigma^a \phi) W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi \tilde{B}}$	$(\phi^\dagger \phi) \tilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi \tilde{W} B}$	$(\phi^\dagger \sigma^a \phi) \tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger \phi) W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger \phi) G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi \tilde{W}}$	$(\phi^\dagger \phi) \tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi \tilde{G}}$	$(\phi^\dagger \phi) \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Class	Label	Operator	Label	Operator
$\psi^2 \phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger \phi)(\bar{\ell}_{i\ell}^j \phi e^{je})$		
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger \phi)(\bar{q}_{iq}^j \phi d^{jd})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger \phi)(\bar{q}_{iq}^j \phi u^{ju})$
$\psi^2 X \phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j \sigma^{\mu\nu} e^{je}) \phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j \sigma^{\mu\nu} e^{je}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} u^{ju}) \tilde{\phi} B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} u^{ju}) \sigma^a \tilde{\phi} W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} d^{jd}) \phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} d^{jd}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} T^A u^{ju}) \tilde{\phi} G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} T^A d^{jd}) \phi G_{\mu\nu}^A$

Procedure outline

$$\omega_4 \sim (3, 1)_{-4/3}$$



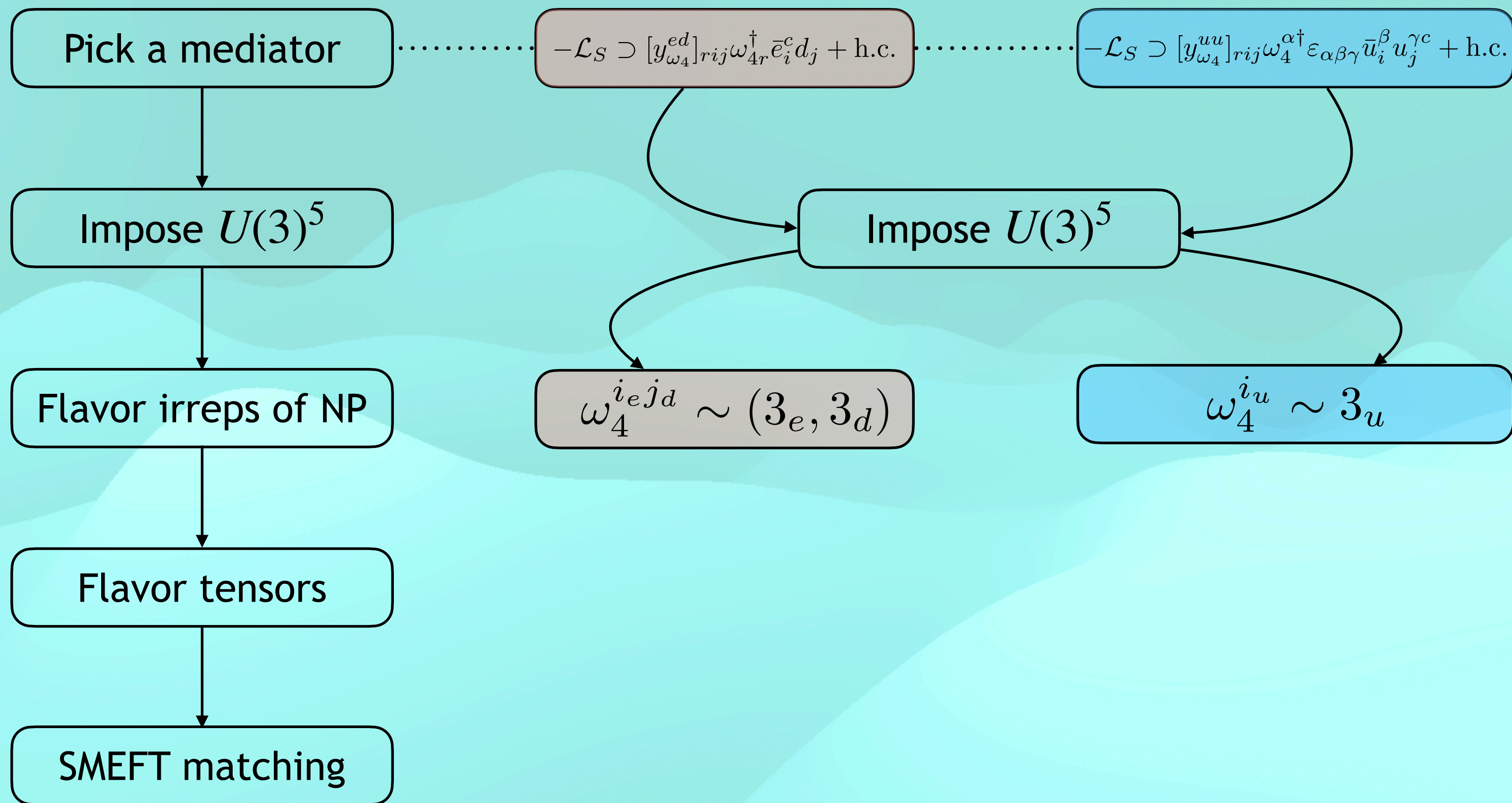
Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{q}_j \gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i \gamma^\mu q^j)(\bar{q}_j \gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i \gamma^\mu \sigma^a q^j)(\bar{q}_j \gamma_\mu \sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i \gamma^\mu e^i)(\bar{e}_j \gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i \gamma^\mu d^j)(\bar{d}_j \gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i \gamma^\mu u^j)(\bar{u}_j \gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i \gamma^\mu u^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i \gamma^\mu e^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i \gamma^\mu T^A u^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{u}_j \gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i \gamma^\mu q^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{u}_j \gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{d}_j \gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$\psi^2 \phi^2 D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{\ell}_i \gamma^\mu \ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{e}_i \gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{u}_i \gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{q}_i \gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{d}_i \gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_i \gamma^\mu \sigma^a q^i)$		

Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc} W_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc} \tilde{W}_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger \phi)^3$		
$\phi^4 D^2$	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger \phi) \Box (\phi^\dagger \phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu \phi) [(D^\mu \phi)^\dagger \phi]$
$X^2 \phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger \phi) B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger \sigma^a \phi) W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi \tilde{B}}$	$(\phi^\dagger \phi) \tilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi \tilde{W} B}$	$(\phi^\dagger \sigma^a \phi) \tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger \phi) W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger \phi) G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi \tilde{W}}$	$(\phi^\dagger \phi) \tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi \tilde{G}}$	$(\phi^\dagger \phi) \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$

Class	Label	Operator	Label	Operator
$\psi^2 \phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger \phi)(\bar{\ell}_{i\ell}^j \phi e^{je})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger \phi)(\bar{q}_{iq}^j \phi u^{ju})$
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger \phi)(\bar{q}_{iq}^j \phi d^{jd})$		
$\psi^2 X \phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j \sigma^{\mu\nu} e^{je}) \phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j \sigma^{\mu\nu} e^{je}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} u^{ju}) \tilde{\phi} B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} u^{ju}) \sigma^a \tilde{\phi} W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} d^{jd}) \phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} d^{jd}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} T^A u^{ju}) \tilde{\phi} G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} T^A d^{jd}) \phi G_{\mu\nu}^A$

Procedure outline

$$\omega_4 \sim (3, 1)_{-4/3}$$



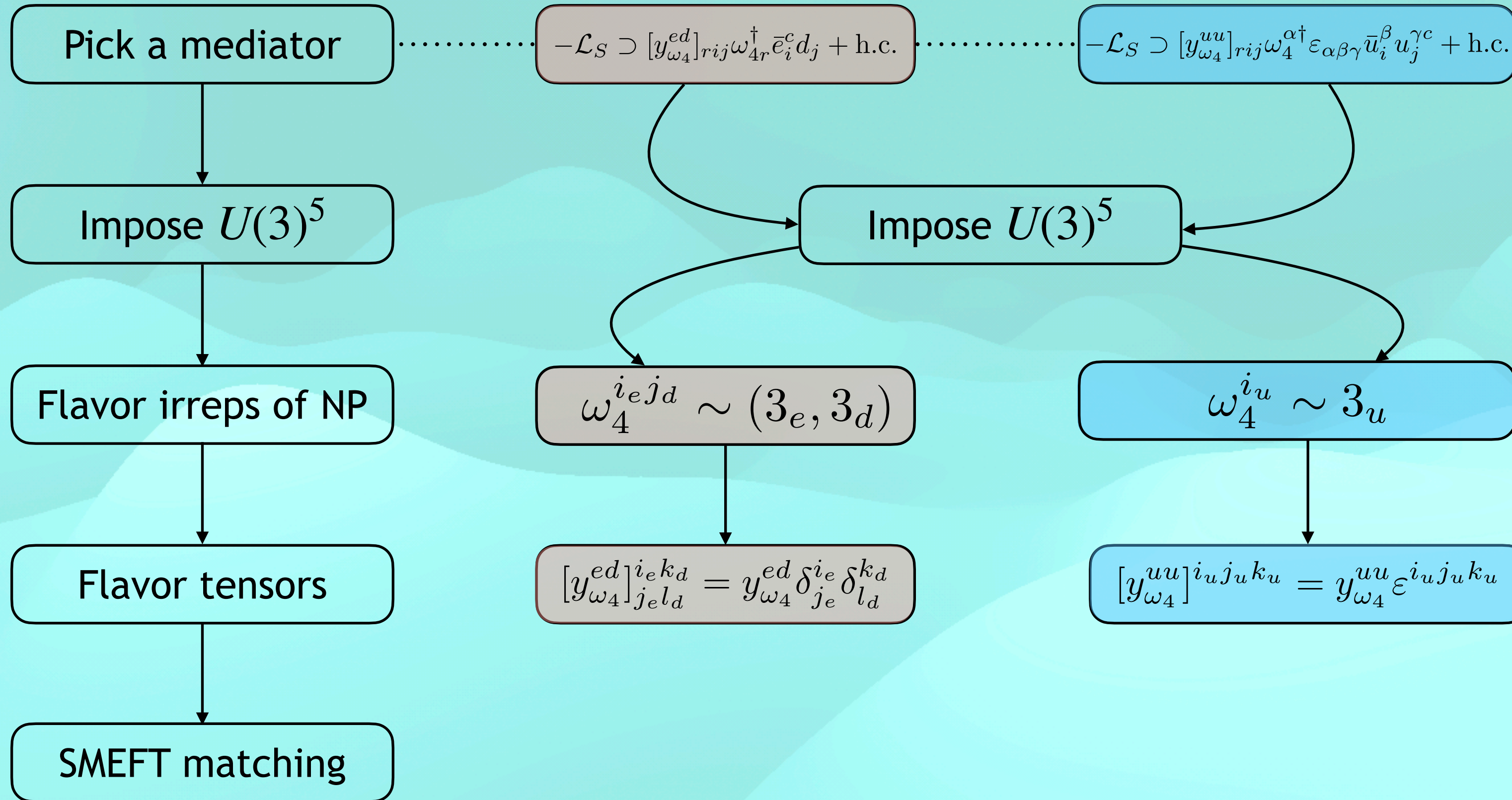
Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{q}_j \gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i \gamma^\mu e^i)(\bar{e}_j \gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i \gamma^\mu u^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i \gamma^\mu e^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i \gamma^\mu T^A u^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{le}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{u}_j \gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i \gamma^\mu q^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{u}_j \gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{ld}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{d}_j \gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$\psi^2 \phi^2 D$	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{\ell}_i \gamma^\mu \ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{e}_i \gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{u}_i \gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{q}_i \gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{d}_i \gamma^\mu d^i)$
	$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_i \gamma^\mu \sigma^a q^i)$		

Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc} W_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc} \tilde{W}_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger \phi)^3$		
$\phi^4 D^2$	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger \phi)\Box(\phi^\dagger \phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu \phi)[(D^\mu \phi)^\dagger \phi]$
$X^2 \phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger \phi) B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger \sigma^a \phi) W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi \tilde{B}}$	$(\phi^\dagger \phi) \tilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi \tilde{W} B}$	$(\phi^\dagger \sigma^a \phi) \tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger \phi) W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger \phi) G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi \tilde{W}}$	$(\phi^\dagger \phi) \tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi \tilde{G}}$	$(\phi^\dagger \phi) \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$

Class	Label	Operator	Label	Operator
$\psi^2 \phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger \phi)(\bar{\ell}_{i\ell}^j \phi e^{je})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger \phi)(\bar{q}_{iq}^j \phi u^{ju})$
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger \phi)(\bar{q}_{iq}^j \phi d^{jd})$		
$\psi^2 X \phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j \sigma^{\mu\nu} e^{je}) \phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell}^j \sigma^{\mu\nu} e^{je}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} u^{ju}) \tilde{\phi} B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} u^{ju}) \sigma^a \tilde{\phi} W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} d^{jd}) \phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} d^{jd}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} T^A u^{ju}) \tilde{\phi} G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq}^j \sigma^{\mu\nu} T^A d^{jd}) \phi G_{\mu\nu}^A$

Procedure outline

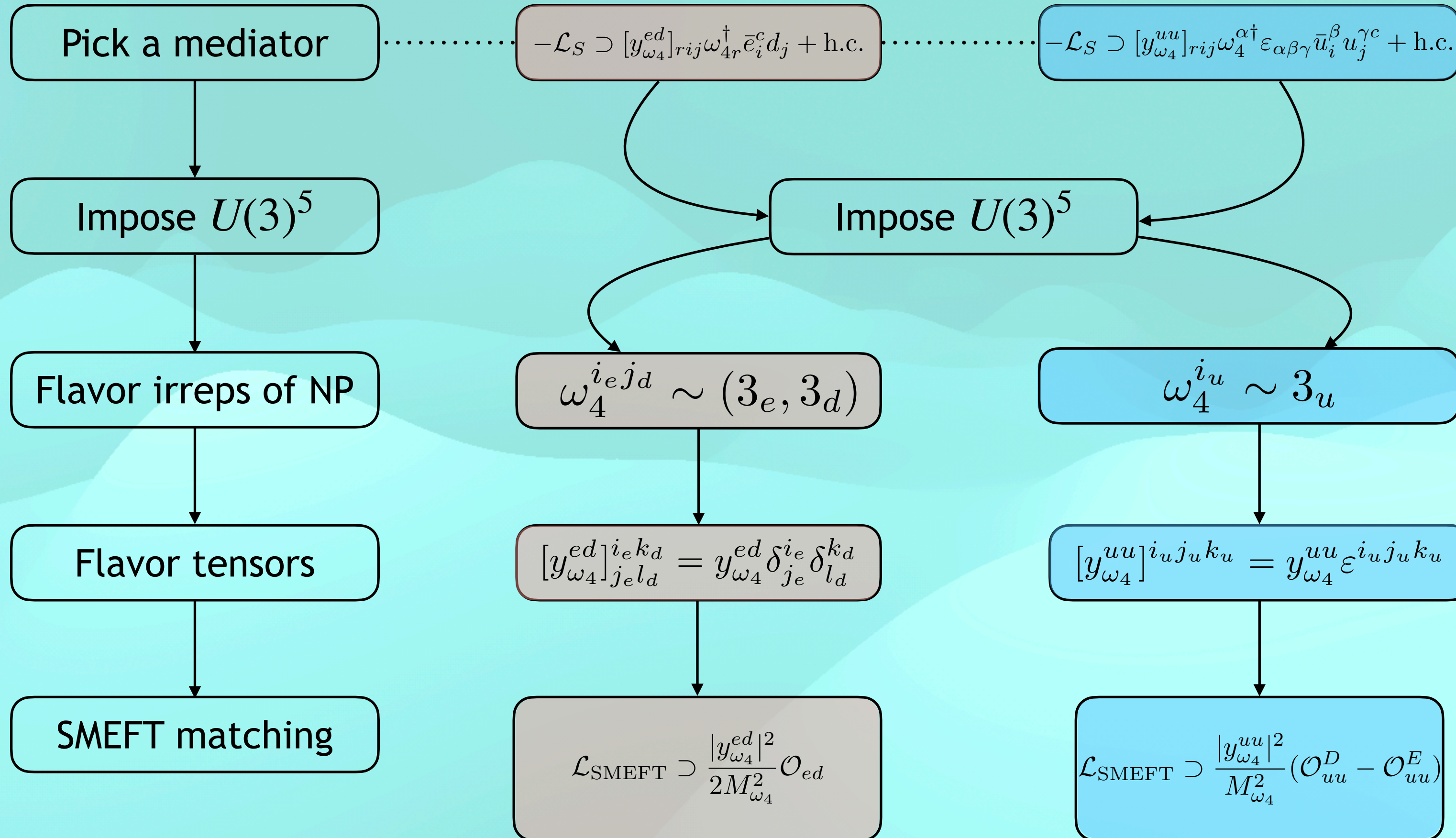
$$\omega_4 \sim (3, 1)_{-4/3}$$



Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{q}_j \gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i \gamma^\mu e^i)(\bar{e}_j \gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i \gamma^\mu u^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i \gamma^\mu e^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i \gamma^\mu T^A u^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{ed}	$(\bar{e}_i \gamma^\mu e^i)(\bar{d}_j \gamma_\mu d^j)$		
	\mathcal{O}_{le}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{u}_j \gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i \gamma^\mu q^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{u}_j \gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{d}_j \gamma_\mu d^j)$
$\psi^2 \phi^2 D$	\mathcal{O}_{ld}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{d}_j \gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{d}_j \gamma_\mu T^A d^j)$
	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{\ell}_i \gamma^\mu \ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{e}_i \gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{u}_i \gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{q}_i \gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{d}_i \gamma^\mu d^i)$
$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_i \gamma^\mu \sigma^a q^i)$			
Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc} W_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc} \tilde{W}_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger \phi)^3$		
$\phi^4 D^2$	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger \phi)\Box(\phi^\dagger \phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu \phi)[(D^\mu \phi)^\dagger \phi]$
$X^2 \phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger \phi) B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger \sigma^a \phi) W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi \tilde{B}}$	$(\phi^\dagger \phi) \tilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi \tilde{W} B}$	$(\phi^\dagger \sigma^a \phi) \tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger \phi) W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger \phi) G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi \tilde{W}}$	$(\phi^\dagger \phi) \tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi \tilde{G}}$	$(\phi^\dagger \phi) \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Class	Label	Operator	Label	Operator
$\psi^2 \phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger \phi)(\bar{\ell}_i \phi e^{je})$		
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger \phi)(\bar{q}_i \phi d^{jd})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger \phi)(\bar{q}_i \phi u^{ju})$
$\psi^2 X \phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_i \sigma^{\mu\nu} e^{je}) \phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_i \sigma^{\mu\nu} e^{je}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_i \sigma^{\mu\nu} u^{ju}) \phi B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_i \sigma^{\mu\nu} u^{ju}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_i \sigma^{\mu\nu} d^{jd}) \phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_i \sigma^{\mu\nu} d^{jd}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_i \sigma^{\mu\nu} T^A u^{ju}) \phi G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_i \sigma^{\mu\nu} T^A d^{jd}) \phi G_{\mu\nu}^A$

Procedure outline

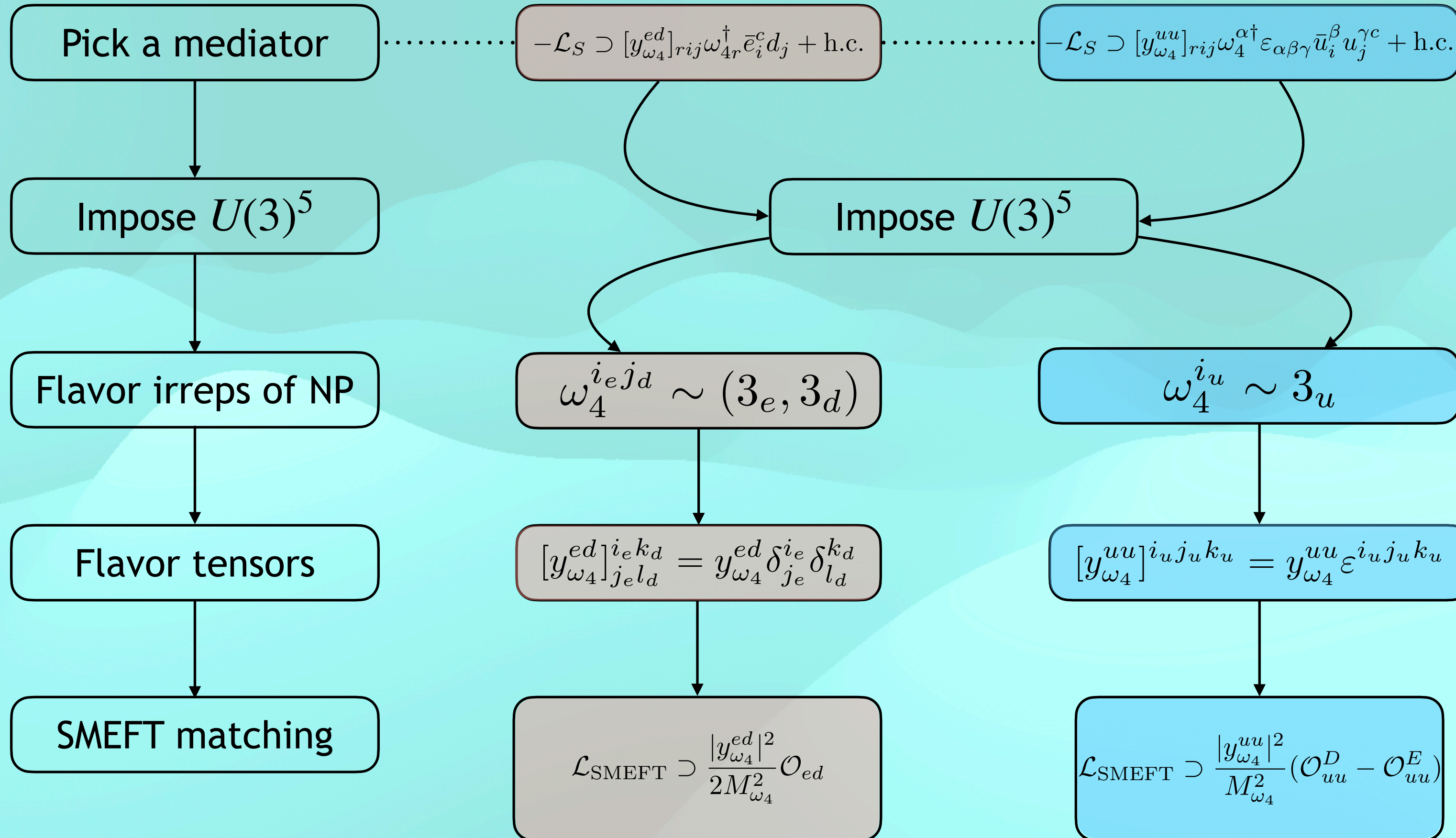
$$\omega_4 \sim (3, 1)_{-4/3}$$



Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{q}_j \gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i \gamma^\mu e^i)(\bar{e}_j \gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i \gamma^\mu u^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i \gamma^\mu e^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i \gamma^\mu T^A u^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{ed}	$(\bar{e}_i \gamma^\mu e^i)(\bar{d}_j \gamma_\mu d^j)$		
	\mathcal{O}_{le}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{u}_j \gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i \gamma^\mu q^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{u}_j \gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{d}_j \gamma_\mu d^j)$
$\psi^2 \phi^2 D$	\mathcal{O}_{ld}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{d}_j \gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{d}_j \gamma_\mu T^A d^j)$
	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{\ell}_i \gamma^\mu \ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{e}_i \gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{u}_i \gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{q}_i \gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{d}_i \gamma^\mu d^i)$
$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_i \gamma^\mu \sigma^a q^i)$			
Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc} W_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc} \tilde{W}_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger \phi)^3$		
$\phi^4 D^2$	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger \phi)\Box(\phi^\dagger \phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu \phi)[(D^\mu \phi)^\dagger \phi]$
$X^2 \phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger \phi) B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger \sigma^a \phi) W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi \tilde{B}}$	$(\phi^\dagger \phi) \tilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi \tilde{W} B}$	$(\phi^\dagger \sigma^a \phi) \tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger \phi) W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger \phi) G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi \tilde{W}}$	$(\phi^\dagger \phi) \tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi \tilde{G}}$	$(\phi^\dagger \phi) \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$
Class	Label	Operator	Label	Operator
$\psi^2 \phi^3$	$[\mathcal{O}_{e\phi}]_{i_\ell}^{j_e}$	$(\phi^\dagger \phi)(\bar{\ell}_{i_\ell} \phi e^{j_e})$		
	$[\mathcal{O}_{d\phi}]_{i_q}^{j_d}$	$(\phi^\dagger \phi)(\bar{q}_{i_q} \phi d^{j_d})$	$[\mathcal{O}_{u\phi}]_{i_q}^{j_u}$	$(\phi^\dagger \phi)(\bar{q}_{i_q} \phi u^{j_u})$
$\psi^2 X \phi$ Loop generated	$[\mathcal{O}_{eB}]_{i_\ell}^{j_e}$	$(\bar{\ell}_{i_\ell} \sigma^{\mu\nu} e^{j_e}) \phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i_\ell}^{j_e}$	$(\bar{\ell}_{i_\ell} \sigma^{\mu\nu} e^{j_e}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{i_q}^{j_u}$	$(\bar{q}_{i_q} \sigma^{\mu\nu} u^{j_u}) \phi B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{i_q}^{j_u}$	$(\bar{q}_{i_q} \sigma^{\mu\nu} u^{j_u}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{i_q}^{j_d}$	$(\bar{q}_{i_q} \sigma^{\mu\nu} d^{j_d}) \phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{i_q}^{j_d}$	$(\bar{q}_{i_q} \sigma^{\mu\nu} d^{j_d}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{i_q}^{j_u}$	$(\bar{q}_{i_q} \sigma^{\mu\nu} T^A u^{j_u}) \phi G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{i_q}^{j_d}$	$(\bar{q}_{i_q} \sigma^{\mu\nu} T^A d^{j_d}) \phi G_{\mu\nu}^A$

Procedure outline

$$\omega_4 \sim (3, 1)_{-4/3}$$



- Similar procedure applied for all other mediators

Class	Label	Operator	Label	Operator
$(\bar{L}L)(\bar{L}L)$	$\mathcal{O}_{\ell\ell}^D$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^j)$	$\mathcal{O}_{\ell q}^{(1)}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{q}_j \gamma_\mu q^j)$
	$\mathcal{O}_{\ell\ell}^E$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{\ell}_j \gamma_\mu \ell^i)$	$\mathcal{O}_{\ell q}^{(3)}$	$(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)D}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^j)$	$\mathcal{O}_{qq}^{(3)D}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^j)$
	$\mathcal{O}_{qq}^{(1)E}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{q}_j \gamma_\mu q^i)$	$\mathcal{O}_{qq}^{(3)E}$	$(\bar{q}_i \gamma^\mu \sigma^a q^i)(\bar{q}_j \gamma_\mu \sigma^a q^i)$
$(\bar{R}R)(\bar{R}R)$	\mathcal{O}_{ee}	$(\bar{e}_i \gamma^\mu e^i)(\bar{e}_j \gamma_\mu e^j)$	\mathcal{O}_{dd}^D	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{uu}^D	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^j)$	\mathcal{O}_{dd}^E	$(\bar{d}_i \gamma^\mu d^i)(\bar{d}_j \gamma_\mu d^i)$
	\mathcal{O}_{uu}^E	$(\bar{u}_i \gamma^\mu u^i)(\bar{u}_j \gamma_\mu u^i)$	$\mathcal{O}_{ud}^{(1)}$	$(\bar{u}_i \gamma^\mu u^i)(\bar{d}_j \gamma_\mu d^j)$
	\mathcal{O}_{eu}	$(\bar{e}_i \gamma^\mu e^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{ud}^{(8)}$	$(\bar{u}_i \gamma^\mu T^A u^i)(\bar{d}_j \gamma_\mu T^A d^j)$
$(\bar{L}L)(\bar{R}R)$	\mathcal{O}_{ed}	$(\bar{e}_i \gamma^\mu e^i)(\bar{d}_j \gamma_\mu d^j)$		
	\mathcal{O}_{le}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{u}_j \gamma_\mu u^j)$
	\mathcal{O}_{qe}	$(\bar{q}_i \gamma^\mu q^i)(\bar{e}_j \gamma_\mu e^j)$	$\mathcal{O}_{qu}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{u}_j \gamma_\mu T^A u^j)$
	\mathcal{O}_{lu}	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{u}_j \gamma_\mu u^j)$	$\mathcal{O}_{qd}^{(1)}$	$(\bar{q}_i \gamma^\mu q^i)(\bar{d}_j \gamma_\mu d^j)$
$\psi^2 \phi^2 D$	$\mathcal{O}_{\ell d}$	$(\bar{\ell}_i \gamma^\mu \ell^i)(\bar{d}_j \gamma_\mu d^j)$	$\mathcal{O}_{qd}^{(8)}$	$(\bar{q}_i \gamma^\mu T^A q^i)(\bar{d}_j \gamma_\mu T^A d^j)$
	$\mathcal{O}_{\phi\ell}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{\ell}_i \gamma^\mu \ell^i)$	$\mathcal{O}_{\phi e}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{e}_i \gamma^\mu e^i)$
	$\mathcal{O}_{\phi\ell}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{\ell}_i \gamma^\mu \sigma^a \ell^i)$	$\mathcal{O}_{\phi u}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{u}_i \gamma^\mu u^i)$
	$\mathcal{O}_{\phi q}^{(1)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{q}_i \gamma^\mu q^i)$	$\mathcal{O}_{\phi d}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu \phi)(\bar{d}_i \gamma^\mu d^i)$
$\mathcal{O}_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_i \gamma^\mu \sigma^a q^i)$			

Class	Label	Operator	Label	Operator
X^3 Loop generated	\mathcal{O}_W	$\varepsilon_{abc} W_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	\mathcal{O}_G	$f_{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
	$\mathcal{O}_{\tilde{W}}$	$\varepsilon_{abc} \tilde{W}_\mu^{a\nu} W_\nu^{b\rho} W_\rho^{c\mu}$	$\mathcal{O}_{\tilde{G}}$	$f_{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$
ϕ^6	\mathcal{O}_ϕ	$(\phi^\dagger \phi)^3$		
$\phi^4 D^2$	$\mathcal{O}_{\phi\Box}$	$(\phi^\dagger \phi)\Box(\phi^\dagger \phi)$	$\mathcal{O}_{\phi D}$	$(\phi^\dagger D_\mu \phi)[(D^\mu \phi)^\dagger \phi]$
$X^2 \phi^2$ Loop generated	$\mathcal{O}_{\phi B}$	$(\phi^\dagger \phi) B_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi WB}$	$(\phi^\dagger \sigma^a \phi) W_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi \tilde{B}}$	$(\phi^\dagger \phi) \tilde{B}_{\mu\nu} B^{\mu\nu}$	$\mathcal{O}_{\phi \tilde{W} B}$	$(\phi^\dagger \sigma^a \phi) \tilde{W}_{\mu\nu}^a B^{\mu\nu}$
	$\mathcal{O}_{\phi W}$	$(\phi^\dagger \phi) W_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi G}$	$(\phi^\dagger \phi) G_{\mu\nu}^A G^{A\mu\nu}$
	$\mathcal{O}_{\phi \tilde{W}}$	$(\phi^\dagger \phi) \tilde{W}_{\mu\nu}^a W^{a\mu\nu}$	$\mathcal{O}_{\phi \tilde{G}}$	$(\phi^\dagger \phi) \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$

Class	Label	Operator	Label	Operator
$\psi^2 \phi^3$	$[\mathcal{O}_{e\phi}]_{i\ell}^{je}$	$(\phi^\dagger \phi)(\bar{\ell}_{i\ell} \phi e^{je})$	$[\mathcal{O}_{u\phi}]_{iq}^{ju}$	$(\phi^\dagger \phi)(\bar{q}_{iq} \phi u^{ju})$
	$[\mathcal{O}_{d\phi}]_{iq}^{jd}$	$(\phi^\dagger \phi)(\bar{q}_{iq} \phi d^{jd})$		
$\psi^2 X \phi$ Loop generated	$[\mathcal{O}_{eB}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell} \sigma^{\mu\nu} e^{je}) \phi B_{\mu\nu}$	$[\mathcal{O}_{eW}]_{i\ell}^{je}$	$(\bar{\ell}_{i\ell} \sigma^{\mu\nu} e^{je}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uB}]_{iq}^{ju}$	$(\bar{q}_{iq} \sigma^{\mu\nu} u^{ju}) \tilde{\phi} B_{\mu\nu}$	$[\mathcal{O}_{uW}]_{iq}^{ju}$	$(\bar{q}_{iq} \sigma^{\mu\nu} u^{ju}) \sigma^a \tilde{\phi} W_{\mu\nu}^a$
	$[\mathcal{O}_{dB}]_{iq}^{jd}$	$(\bar{q}_{iq} \sigma^{\mu\nu} d^{jd}) \phi B_{\mu\nu}$	$[\mathcal{O}_{dW}]_{iq}^{jd}$	$(\bar{q}_{iq} \sigma^{\mu\nu} d^{jd}) \sigma^a \phi W_{\mu\nu}^a$
	$[\mathcal{O}_{uG}]_{iq}^{ju}$	$(\bar{q}_{iq} \sigma^{\mu\nu} T^A u^{ju}) \tilde{\phi} G_{\mu\nu}^A$	$[\mathcal{O}_{dG}]_{iq}^{jd}$	$(\bar{q}_{iq} \sigma^{\mu\nu} T^A d^{jd}) \phi G_{\mu\nu}^A$

Leading directions

- Classification of all NP mediators

Field	Irrep	Normalization	Operator
$\mathcal{S}_1 \sim (1, 1)_1$	$\mathbf{3}_\ell$	$ y_{\mathcal{S}_1} ^2/M_{\mathcal{S}_1}^2$	$\mathcal{O}_{\ell\ell}^D - \mathcal{O}_{\ell\ell}^E$
$\mathcal{S}_2 \sim (1, 1)_2$	$\bar{\mathbf{6}}_e$	$ y_{\mathcal{S}_2} ^2/(2M_{\mathcal{S}_2}^2)$	\mathcal{O}_{ee}
	$(\bar{\mathbf{3}}_e, \mathbf{3}_\ell)$	$- y_\varphi^e ^2/(2M_\varphi^2)$	$\mathcal{O}_{\ell e}$
$\varphi \sim (1, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\varphi^d ^2/(6M_\varphi^2)$	$\mathcal{O}_{qd}^{(1)} + 6\mathcal{O}_{qd}^{(8)}$
	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\varphi^u ^2/(6M_\varphi^2)$	$\mathcal{O}_{qu}^{(1)} + 6\mathcal{O}_{qu}^{(8)}$
$\Xi_1 \sim (1, 3)_1$	$\bar{\mathbf{6}}_\ell$	$ y_{\Xi_1} ^2/(2M_{\Xi_1}^2)$	$\mathcal{O}_{\ell\ell}^D + \mathcal{O}_{\ell\ell}^E$
	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_{\omega_1}^{q\ell} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
	$(\mathbf{3}_e, \mathbf{3}_u)$	$ y_{\omega_1}^{eu} ^2/(2M_{\omega_1}^2)$	\mathcal{O}_{eu}
$\omega_1 \sim (3, 1)_{-\frac{1}{3}}$	$\bar{\mathbf{6}}_q$	$ y_{\omega_1}^{qq} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} + \mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_u)$	$ y_{\omega_1}^{du} ^2/(3M_{\omega_1}^2)$	$\mathcal{O}_{ud}^{(1)} - 3\mathcal{O}_{ud}^{(8)}$
$\omega_2 \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_d$	$ y_{\omega_2} ^2/M_{\omega_2}^2$	$\mathcal{O}_{dd}^D - \mathcal{O}_{dd}^E$
	$(\mathbf{3}_e, \mathbf{3}_d)$	$ y_{\omega_4}^{ed} ^2/(2M_{\omega_4}^2)$	\mathcal{O}_{ed}
$\omega_4 \sim (3, 1)_{-\frac{4}{3}}$	$\mathbf{3}_u$	$ y_{\omega_4}^{uu} ^2/M_{\omega_4}^2$	$\mathcal{O}_{uu}^D - \mathcal{O}_{uu}^E$
$\Pi_1 \sim (3, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_d)$	$- y_{\Pi_1} ^2/(2M_{\Pi_1}^2)$	$\mathcal{O}_{\ell d}$
	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_u)$	$- y_{\Pi_7}^{\ell u} ^2/(2M_{\Pi_7}^2)$	$\mathcal{O}_{\ell u}$
$\Pi_7 \sim (3, 2)_{\frac{7}{6}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_q)$	$- y_{\Pi_7}^{qe} ^2/(2M_{\Pi_7}^2)$	\mathcal{O}_{qe}
	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_\zeta^{q\ell} ^2/(4M_\zeta^2)$	$3\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
$\zeta \sim (3, 3)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$ y_\zeta^{qq} ^2/(2M_\zeta^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
	$(\mathbf{3}_u, \mathbf{3}_d)$	$ y_{\Omega_1}^{ud} ^2/(6M_{\Omega_1}^2)$	$2\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
	$\bar{\mathbf{3}}_q$	$ y_{\Omega_1}^{qq} ^2/(4M_{\Omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} - \mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Omega_2 \sim (6, 1)_{-\frac{2}{3}}$	$\mathbf{6}_d$	$ y_{\Omega_2} ^2/(4M_{\Omega_2}^2)$	$\mathcal{O}_{dd}^D + \mathcal{O}_{dd}^E$
$\Omega_4 \sim (6, 1)_{\frac{4}{3}}$	$\mathbf{6}_u$	$ y_{\Omega_4} ^2/(4M_{\Omega_4}^2)$	$\mathcal{O}_{uu}^D + \mathcal{O}_{uu}^E$
$\Upsilon \sim (6, 3)_{\frac{1}{3}}$	$\mathbf{6}_q$	$ y_\Upsilon ^2/(8M_\Upsilon^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} + 3\mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\Phi^{qu} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
$\Phi \sim (8, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\Phi^{dq} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$

Field	Irrep	Normalization	Operator
	$\mathbf{8}_\ell$	$-(g_B^\ell)^2/(12M_B^2)$	$3\mathcal{O}_{\ell\ell}^E - \mathcal{O}_{\ell\ell}^D$
	$\mathbf{8}_e$	$-(g_B^e)^2/(6M_B^2)$	\mathcal{O}_{ee}
$\mathcal{B} \sim (1, 1)_0$	$\mathbf{8}_q$	$-(g_B^q)^2/(12M_B^2)$	$3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(1)D}$
	$\mathbf{8}_u$	$-(g_B^u)^2/(12M_B^2)$	$3\mathcal{O}_{uu}^E - \mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$-(g_B^d)^2/(12M_B^2)$	$3\mathcal{O}_{dd}^E - \mathcal{O}_{dd}^D$
$\mathcal{B}_1 \sim (1, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$- g_{\mathcal{B}_1}^{du} ^2/(3M_{\mathcal{B}_1}^2)$	$\mathcal{O}_{ud}^{(1)} + 6\mathcal{O}_{ud}^{(8)}$
	$\mathbf{8}_q$	$-(g_{\mathcal{W}}^q)^2/(48M_{\mathcal{W}}^2)$	$3\mathcal{O}_{qq}^{(3)E} - \mathcal{O}_{qq}^{(3)D}$
$\mathcal{W} \sim (1, 3)_0$	$\mathbf{8}_\ell$	$(g_{\mathcal{W}}^\ell)^2/(48M_{\mathcal{W}}^2)$	$5\mathcal{O}_{\ell\ell}^E - 7\mathcal{O}_{\ell\ell}^D$
$\mathcal{L}_3 \sim (1, 2)_{-\frac{3}{2}}$	$(\mathbf{3}_e, \mathbf{3}_\ell)$	$ g_{\mathcal{L}_3} ^2/M_{\mathcal{L}_3}^2$	$\mathcal{O}_{\ell e}$
	$(\bar{\mathbf{3}}_e, \mathbf{3}_d)$	$- g_{\mathcal{U}_2}^{ed} ^2/M_{\mathcal{U}_2}^2$	\mathcal{O}_{ed}
$\mathcal{U}_2 \sim (3, 1)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{U}_2}^{\ell q} ^2/(2M_{\mathcal{U}_2}^2)$	$\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{U}_5 \sim (3, 1)_{\frac{5}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_u)$	$- g_{\mathcal{U}_5} ^2/M_{\mathcal{U}_5}^2$	\mathcal{O}_{eu}
	$(\mathbf{3}_u, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_1}^{u\ell} ^2/M_{\mathcal{Q}_1}^2$	$\mathcal{O}_{\ell u}$
$\mathcal{Q}_1 \sim (3, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_1}^{dq} ^2/(3M_{\mathcal{Q}_1}^2)$	$\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$
	$(\mathbf{3}_d, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_5}^{d\ell} ^2/M_{\mathcal{Q}_5}^2$	$\mathcal{O}_{\ell d}$
$\mathcal{Q}_5 \sim (3, 2)_{-\frac{5}{6}}$	$(\mathbf{3}_e, \mathbf{3}_q)$	$ g_{\mathcal{Q}_5}^{eq} ^2/M_{\mathcal{Q}_5}^2$	\mathcal{O}_{qe}
	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_5}^{uq} ^2/(3M_{\mathcal{Q}_5}^2)$	$\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{X} \sim (3, 3)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{X}} ^2/(8M_{\mathcal{X}}^2)$	$3\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{Y}_1 \sim (\bar{6}, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_1} ^2/(3M_{\mathcal{Y}_1}^2)$	$2\mathcal{O}_{qd}^{(1)} + 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Y}_5 \sim (\bar{6}, 2)_{-\frac{5}{6}}$	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_5} ^2/(3M_{\mathcal{Y}_5}^2)$	$2\mathcal{O}_{qu}^{(1)} + 3\mathcal{O}_{qu}^{(8)}$
	$\mathbf{8}_q$	$-(g_{\mathcal{G}}^q)^2/(144M_{\mathcal{G}}^2)$	$11\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} + 9\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$
$\mathcal{G} \sim (8, 1)_0$	$\mathbf{8}_u$	$(g_{\mathcal{G}}^u)^2/(36M_{\mathcal{G}}^2)$	$3\mathcal{O}_{uu}^E - 5\mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$(g_{\mathcal{G}}^d)^2/(36M_{\mathcal{G}}^2)$	$3\mathcal{O}_{dd}^E - 5\mathcal{O}_{dd}^D$
$\mathcal{G}_1 \sim (8, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$ g_{\mathcal{G}_1} ^2/(9M_{\mathcal{G}_1}^2)$	$-4\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
$\mathcal{H} \sim (8, 3)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{H}})^2/(576M_{\mathcal{H}}^2)$	$27\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} - 7\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$

Field	Irrep	Normalization	Operator
$N \sim (1, 1)_0$	$\mathbf{3}_\ell$	$ \lambda_N ^2/(4M_N^2)$	$\mathcal{O}_{\phi\ell}^{(1)} - \mathcal{O}_{\phi\ell}^{(3)}$
$E \sim (1, 1)_{-1}$	$\mathbf{3}_\ell$	$- \lambda_E ^2/(4M_E^2)$	$\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} - [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_1 \sim (1, 2)_{-\frac{1}{2}}$	$\mathbf{3}_e$	$ \lambda_{\Delta_1} ^2/(2M_{\Delta_1}^2)$	$\mathcal{O}_{\phi e} + [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_3 \sim (1, 2)_{-\frac{3}{2}}$	$\mathbf{3}_e$	$- \lambda_{\Delta_3} ^2/(2M_{\Delta_3}^2)$	$\mathcal{O}_{\phi e} - [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma \sim (1, 3)_0$	$\mathbf{3}_\ell$	$ \lambda_\Sigma ^2/(16M_\Sigma^2)$	$3\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} + [4y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma_1 \sim (1, 3)_{-1}$	$\mathbf{3}_\ell$	$ \lambda_{\Sigma_1} ^2/(16M_{\Sigma_1}^2)$	$\mathcal{O}_{\phi\ell}^{(3)} - 3\mathcal{O}_{\phi\ell}^{(1)} + [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$U \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_U ^2/(4M_U^2)$	$\mathcal{O}_{\phi q}^{(1)} - \mathcal{O}_{\phi q}^{(3)} + [2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$D \sim (3, 1)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$- \lambda_D ^2/(4M_D^2)$	$\mathcal{O}_{\phi q}^{(1)} + \mathcal{O}_{\phi q}^{(3)} - [2y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
	$\mathbf{3}_u$	$- \lambda_{Q_1}^u ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi u} - [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$Q_1 \sim (3, 2)_{\frac{1}{6}}$	$\mathbf{3}_d$	$ \lambda_{Q_1}^d ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi d} + [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_5 \sim (3, 2)_{-\frac{5}{6}}$	$\mathbf{3}_d$	$- \lambda_{Q_5} ^2/(2M_{Q_5}^2)$	$\mathcal{O}_{\phi d} - [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_7 \sim (3, 2)_{\frac{7}{6}}$	$\mathbf{3}_u$	$ \lambda_{Q_7} ^2/(2M_{Q_7}^2)$	$\mathcal{O}_{\phi u} + [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_1 \sim (3, 3)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_1} ^2/(16M_{T_1}^2)$	$\mathcal{O}_{\phi q}^{(3)} - 3\mathcal{O}_{\phi q}^{(1)} + [2y_d^* \mathcal{O}_{d\phi} + 4y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_2 \sim (3, 3)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_2} ^2/(16M_{T_2}^2)$	$\mathcal{O}_{\phi q}^{(3)} + 3\mathcal{O}_{\phi q}^{(1)} + [4y_d^* \mathcal{O}_{d\phi} + 2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$

Leading directions

- Classification of all NP mediators
- Most flavor irreps match onto a single well-defined linear combination of dimension-6 SMEFT operators

Field	Irrep	Normalization	Operator
$\mathcal{S}_1 \sim (1, 1)_1$	$\mathbf{3}_\ell$	$ y_{\mathcal{S}_1} ^2/M_{\mathcal{S}_1}^2$	$\mathcal{O}_{\ell\ell}^D - \mathcal{O}_{\ell\ell}^E$
$\mathcal{S}_2 \sim (1, 1)_2$	$\bar{\mathbf{6}}_e$	$ y_{\mathcal{S}_2} ^2/(2M_{\mathcal{S}_2}^2)$	\mathcal{O}_{ee}
$\varphi \sim (1, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_\ell)$	$- y_\varphi^e ^2/(2M_\varphi^2)$	$\mathcal{O}_{\ell e}$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\varphi^d ^2/(6M_\varphi^2)$	$\mathcal{O}_{qd}^{(1)} + 6\mathcal{O}_{qd}^{(8)}$
	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\varphi^u ^2/(6M_\varphi^2)$	$\mathcal{O}_{qu}^{(1)} + 6\mathcal{O}_{qu}^{(8)}$
$\Xi_1 \sim (1, 3)_1$	$\bar{\mathbf{6}}_\ell$	$ y_{\Xi_1} ^2/(2M_{\Xi_1}^2)$	$\mathcal{O}_{\ell\ell}^D + \mathcal{O}_{\ell\ell}^E$
$\omega_1 \sim (3, 1)_{-\frac{1}{3}}$	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_{\omega_1}^{\ell\ell} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
	$(\mathbf{3}_e, \mathbf{3}_u)$	$ y_{\omega_1}^{eu} ^2/(2M_{\omega_1}^2)$	\mathcal{O}_{eu}
	$\bar{\mathbf{6}}_q$	$ y_{\omega_1}^{qq} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} + \mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_u)$	$ y_{\omega_1}^{du} ^2/(3M_{\omega_1}^2)$	$\mathcal{O}_{ud}^{(1)} - 3\mathcal{O}_{ud}^{(8)}$
$\omega_2 \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_d$	$ y_{\omega_2} ^2/M_{\omega_2}^2$	$\mathcal{O}_{dd}^D - \mathcal{O}_{dd}^E$
$\omega_4 \sim (3, 1)_{-\frac{4}{3}}$	$(\mathbf{3}_e, \mathbf{3}_d)$	$ y_{\omega_4}^{ed} ^2/(2M_{\omega_4}^2)$	\mathcal{O}_{ed}
	$\mathbf{3}_u$	$ y_{\omega_4}^{uu} ^2/M_{\omega_4}^2$	$\mathcal{O}_{uu}^D - \mathcal{O}_{uu}^E$
$\Pi_1 \sim (3, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_d)$	$- y_{\Pi_1} ^2/(2M_{\Pi_1}^2)$	$\mathcal{O}_{\ell d}$
$\Pi_7 \sim (3, 2)_{\frac{7}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_u)$	$- y_{\Pi_7}^{\ell u} ^2/(2M_{\Pi_7}^2)$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_e, \mathbf{3}_q)$	$- y_{\Pi_7}^{qe} ^2/(2M_{\Pi_7}^2)$	\mathcal{O}_{qe}
$\zeta \sim (3, 3)_{-\frac{1}{3}}$	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_\zeta^{\ell\ell} ^2/(4M_\zeta^2)$	$3\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
	$\mathbf{3}_q$	$ y_\zeta^{qq} ^2/(2M_\zeta^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
$\Omega_1 \sim (6, 1)_{\frac{1}{3}}$	$(\mathbf{3}_u, \mathbf{3}_d)$	$ y_{\Omega_1}^{ud} ^2/(6M_{\Omega_1}^2)$	$2\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
	$\bar{\mathbf{3}}_q$	$ y_{\Omega_1}^{qq} ^2/(4M_{\Omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} - \mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Omega_2 \sim (6, 1)_{-\frac{2}{3}}$	$\mathbf{6}_d$	$ y_{\Omega_2} ^2/(4M_{\Omega_2}^2)$	$\mathcal{O}_{dd}^D + \mathcal{O}_{dd}^E$
$\Omega_4 \sim (6, 1)_{\frac{4}{3}}$	$\mathbf{6}_u$	$ y_{\Omega_4} ^2/(4M_{\Omega_4}^2)$	$\mathcal{O}_{uu}^D + \mathcal{O}_{uu}^E$
$\Upsilon \sim (6, 3)_{\frac{1}{3}}$	$\mathbf{6}_q$	$ y_\Upsilon ^2/(8M_\Upsilon^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} + 3\mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Phi \sim (8, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\Phi^{qu} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\Phi^{dq} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$

Field	Irrep	Normalization	Operator
$\mathcal{B} \sim (1, 1)_0$	$\mathbf{8}_\ell$	$-(g_{\mathcal{B}}^\ell)^2/(12M_{\mathcal{B}}^2)$	$3\mathcal{O}_{\ell\ell}^E - \mathcal{O}_{\ell\ell}^D$
	$\mathbf{8}_e$	$-(g_{\mathcal{B}}^e)^2/(6M_{\mathcal{B}}^2)$	\mathcal{O}_{ee}
	$\mathbf{8}_q$	$-(g_{\mathcal{B}}^q)^2/(12M_{\mathcal{B}}^2)$	$3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(1)D}$
	$\mathbf{8}_u$	$-(g_{\mathcal{B}}^u)^2/(12M_{\mathcal{B}}^2)$	$3\mathcal{O}_{uu}^E - \mathcal{O}_{uu}^D$
$\mathcal{B}_1 \sim (1, 1)_1$	$\mathbf{8}_d$	$-(g_{\mathcal{B}}^d)^2/(12M_{\mathcal{B}}^2)$	$3\mathcal{O}_{dd}^E - \mathcal{O}_{dd}^D$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$- g_{\mathcal{B}_1}^{du} ^2/(3M_{\mathcal{B}_1}^2)$	$\mathcal{O}_{ud}^{(1)} + 6\mathcal{O}_{ud}^{(8)}$
$\mathcal{W} \sim (1, 3)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{W}}^q)^2/(48M_{\mathcal{W}}^2)$	$3\mathcal{O}_{qq}^{(3)E} - \mathcal{O}_{qq}^{(3)D}$
	$\mathbf{8}_\ell$	$(g_{\mathcal{W}}^\ell)^2/(48M_{\mathcal{W}}^2)$	$5\mathcal{O}_{\ell\ell}^E - 7\mathcal{O}_{\ell\ell}^D$
$\mathcal{L}_3 \sim (1, 2)_{-\frac{3}{2}}$	$(\mathbf{3}_e, \mathbf{3}_\ell)$	$ g_{\mathcal{L}_3} ^2/M_{\mathcal{L}_3}^2$	$\mathcal{O}_{\ell e}$
$\mathcal{U}_2 \sim (3, 1)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_d)$	$- g_{\mathcal{U}_2}^{ed} ^2/M_{\mathcal{U}_2}^2$	\mathcal{O}_{ed}
	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{U}_2}^{\ell q} ^2/(2M_{\mathcal{U}_2}^2)$	$\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{U}_5 \sim (3, 1)_{\frac{5}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_u)$	$- g_{\mathcal{U}_5} ^2/M_{\mathcal{U}_5}^2$	\mathcal{O}_{eu}
$\mathcal{Q}_1 \sim (3, 2)_{\frac{1}{6}}$	$(\mathbf{3}_u, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_1}^{\ell\ell} ^2/M_{\mathcal{Q}_1}^2$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_1}^{dq} ^2/(3M_{\mathcal{Q}_1}^2)$	$\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Q}_5 \sim (3, 2)_{-\frac{5}{6}}$	$(\mathbf{3}_d, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_5}^{d\ell} ^2/M_{\mathcal{Q}_5}^2$	$\mathcal{O}_{\ell d}$
	$(\mathbf{3}_e, \mathbf{3}_q)$	$ g_{\mathcal{Q}_5}^{eq} ^2/M_{\mathcal{Q}_5}^2$	\mathcal{O}_{qe}
	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_5}^{uq} ^2/(3M_{\mathcal{Q}_5}^2)$	$\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{X} \sim (3, 3)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{X}} ^2/(8M_{\mathcal{X}}^2)$	$3\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{Y}_1 \sim (\bar{\mathbf{6}}, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_1} ^2/(3M_{\mathcal{Y}_1}^2)$	$2\mathcal{O}_{qd}^{(1)} + 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Y}_5 \sim (\bar{\mathbf{6}}, 2)_{-\frac{5}{6}}$	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_5} ^2/(3M_{\mathcal{Y}_5}^2)$	$2\mathcal{O}_{qu}^{(1)} + 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{G} \sim (8, 1)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{G}}^q)^2/(144M_{\mathcal{G}}^2)$	$11\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} + 9\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$
	$\mathbf{8}_u$	$(g_{\mathcal{G}}^u)^2/(36M_{\mathcal{G}}^2)$	$3\mathcal{O}_{uu}^E - 5\mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$(g_{\mathcal{G}}^d)^2/(36M_{\mathcal{G}}^2)$	$3\mathcal{O}_{dd}^E - 5\mathcal{O}_{dd}^D$
$\mathcal{G}_1 \sim (8, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$ g_{\mathcal{G}_1} ^2/(9M_{\mathcal{G}_1}^2)$	$-4\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
$\mathcal{H} \sim (8, 3)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{H}})^2/(576M_{\mathcal{H}}^2)$	$27\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} - 7\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$

Field	Irrep	Normalization	Operator
$N \sim (1, 1)_0$	$\mathbf{3}_\ell$	$ \lambda_N ^2/(4M_N^2)$	$\mathcal{O}_{\phi\ell}^{(1)} - \mathcal{O}_{\phi\ell}^{(3)}$
$E \sim (1, 1)_{-1}$	$\mathbf{3}_\ell$	$- \lambda_E ^2/(4M_E^2)$	$\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} - [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_1 \sim (1, 2)_{-\frac{1}{2}}$	$\mathbf{3}_e$	$ \lambda_{\Delta_1} ^2/(2M_{\Delta_1}^2)$	$\mathcal{O}_{\phi e} + [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_3 \sim (1, 2)_{-\frac{3}{2}}$	$\mathbf{3}_e$	$- \lambda_{\Delta_3} ^2/(2M_{\Delta_3}^2)$	$\mathcal{O}_{\phi e} - [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma \sim (1, 3)_0$	$\mathbf{3}_\ell$	$ \lambda_\Sigma ^2/(16M_\Sigma^2)$	$3\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} + [4y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma_1 \sim (1, 3)_{-1}$	$\mathbf{3}_\ell$	$ \lambda_{\Sigma_1} ^2/(16M_{\Sigma_1}^2)$	$\mathcal{O}_{\phi\ell}^{(3)} - 3\mathcal{O}_{\phi\ell}^{(1)} + [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$U \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_U ^2/(4M_U^2)$	$\mathcal{O}_{\phi q}^{(1)} - \mathcal{O}_{\phi q}^{(3)} + [2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$D \sim (3, 1)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$- \lambda_D ^2/(4M_D^2)$	$\mathcal{O}_{\phi q}^{(1)} + \mathcal{O}_{\phi q}^{(3)} - [2y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_1 \sim (3, 2)_{\frac{1}{6}}$	$\mathbf{3}_u$	$- \lambda_{Q_1}^u ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi u} - [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
	$\mathbf{3}_d$	$ \lambda_{Q_1}^d ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi d} + [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_5 \sim (3, 2)_{-\frac{5}{6}}$	$\mathbf{3}_d$	$- \lambda_{Q_5} ^2/(2M_{Q_5}^2)$	$\mathcal{O}_{\phi d} - [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_7 \sim (3, 2)_{\frac{7}{6}}$	$\mathbf{3}_u$	$ \lambda_{Q_7} ^2/(2M_{Q_7}^2)$	$\mathcal{O}_{\phi u} + [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_1 \sim (3, 3)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_1} ^2/(16M_{T_1}^2)$	$\mathcal{O}_{\phi q}^{(3)} - 3\mathcal{O}_{\phi q}^{(1)} + [2y_d^* \mathcal{O}_{d\phi} + 4y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_2 \sim (3, 3)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_2} ^2/(16M_{T_2}^2)$	$\mathcal{O}_{\phi q}^{(3)} + 3\mathcal{O}_{\phi q}^{(1)} + [4y_d^* \mathcal{O}_{d\phi} + 2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$

Leading directions

- Classification of all NP mediators
- Most flavor irreps match onto a single well-defined linear combination of dimension-6 SMEFT operators
- These linear combinations are denoted as leading SMEFT directions

Field	Irrep	Normalization	Operator
$\mathcal{S}_1 \sim (1, 1)_1$	$\mathbf{3}_\ell$	$ y_{\mathcal{S}_1} ^2/M_{\mathcal{S}_1}^2$	$\mathcal{O}_{\ell\ell}^D - \mathcal{O}_{\ell\ell}^E$
$\mathcal{S}_2 \sim (1, 1)_2$	$\bar{\mathbf{6}}_e$	$ y_{\mathcal{S}_2} ^2/(2M_{\mathcal{S}_2}^2)$	\mathcal{O}_{ee}
$\varphi \sim (1, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_\ell)$	$- y_\varphi^e ^2/(2M_\varphi^2)$	$\mathcal{O}_{\ell e}$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\varphi^d ^2/(6M_\varphi^2)$	$\mathcal{O}_{qd}^{(1)} + 6\mathcal{O}_{qd}^{(8)}$
	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\varphi^u ^2/(6M_\varphi^2)$	$\mathcal{O}_{qu}^{(1)} + 6\mathcal{O}_{qu}^{(8)}$
$\Xi_1 \sim (1, 3)_1$	$\bar{\mathbf{6}}_\ell$	$ y_{\Xi_1} ^2/(2M_{\Xi_1}^2)$	$\mathcal{O}_{\ell\ell}^D + \mathcal{O}_{\ell\ell}^E$
$\omega_1 \sim (3, 1)_{-\frac{1}{3}}$	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_{\omega_1}^{\ell\ell} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
	$(\mathbf{3}_e, \mathbf{3}_u)$	$ y_{\omega_1}^{eu} ^2/(2M_{\omega_1}^2)$	\mathcal{O}_{eu}
	$\bar{\mathbf{6}}_q$	$ y_{\omega_1}^{qq} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} + \mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
$\omega_2 \sim (3, 1)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_u)$	$ y_{\omega_2}^{du} ^2/(3M_{\omega_2}^2)$	$\mathcal{O}_{ud}^{(1)} - 3\mathcal{O}_{ud}^{(8)}$
	$\mathbf{3}_d$	$ y_{\omega_2} ^2/M_{\omega_2}^2$	$\mathcal{O}_{dd}^D - \mathcal{O}_{dd}^E$
$\omega_4 \sim (3, 1)_{-\frac{4}{3}}$	$(\mathbf{3}_e, \mathbf{3}_d)$	$ y_{\omega_4}^{ed} ^2/(2M_{\omega_4}^2)$	\mathcal{O}_{ed}
	$\mathbf{3}_u$	$ y_{\omega_4}^{uu} ^2/M_{\omega_4}^2$	$\mathcal{O}_{uu}^D - \mathcal{O}_{uu}^E$
$\Pi_1 \sim (3, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_d)$	$- y_{\Pi_1} ^2/(2M_{\Pi_1}^2)$	$\mathcal{O}_{\ell d}$
$\Pi_7 \sim (3, 2)_{\frac{7}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_u)$	$- y_{\Pi_7}^{\ell u} ^2/(2M_{\Pi_7}^2)$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_e, \mathbf{3}_q)$	$- y_{\Pi_7}^{qe} ^2/(2M_{\Pi_7}^2)$	\mathcal{O}_{qe}
$\zeta \sim (3, 3)_{-\frac{1}{3}}$	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_\zeta^{\ell\ell} ^2/(4M_\zeta^2)$	$3\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
	$\mathbf{3}_q$	$ y_\zeta^{qq} ^2/(2M_\zeta^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
$\Omega_1 \sim (6, 1)_{\frac{1}{3}}$	$(\mathbf{3}_u, \mathbf{3}_d)$	$ y_{\Omega_1}^{ud} ^2/(6M_{\Omega_1}^2)$	$2\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
	$\bar{\mathbf{3}}_q$	$ y_{\Omega_1}^{qq} ^2/(4M_{\Omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} - \mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Omega_2 \sim (6, 1)_{-\frac{2}{3}}$	$\mathbf{6}_d$	$ y_{\Omega_2} ^2/(4M_{\Omega_2}^2)$	$\mathcal{O}_{dd}^D + \mathcal{O}_{dd}^E$
$\Omega_4 \sim (6, 1)_{\frac{4}{3}}$	$\mathbf{6}_u$	$ y_{\Omega_4} ^2/(4M_{\Omega_4}^2)$	$\mathcal{O}_{uu}^D + \mathcal{O}_{uu}^E$
$\Upsilon \sim (6, 3)_{\frac{1}{3}}$	$\mathbf{6}_q$	$ y_\Upsilon ^2/(8M_\Upsilon^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} + 3\mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Phi \sim (8, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\Phi^{qu} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\Phi^{dq} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$

Field	Irrep	Normalization	Operator
$\mathcal{B} \sim (1, 1)_0$	$\mathbf{8}_\ell$	$-(g_\mathcal{B}^\ell)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{\ell\ell}^E - \mathcal{O}_{\ell\ell}^D$
	$\mathbf{8}_e$	$-(g_\mathcal{B}^e)^2/(6M_\mathcal{B}^2)$	\mathcal{O}_{ee}
	$\mathbf{8}_q$	$-(g_\mathcal{B}^q)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(1)D}$
	$\mathbf{8}_u$	$-(g_\mathcal{B}^u)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{uu}^E - \mathcal{O}_{uu}^D$
$\mathcal{B}_1 \sim (1, 1)_1$	$\mathbf{8}_d$	$-(g_\mathcal{B}^d)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{dd}^E - \mathcal{O}_{dd}^D$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$- g_{\mathcal{B}_1}^{du} ^2/(3M_{\mathcal{B}_1}^2)$	$\mathcal{O}_{ud}^{(1)} + 6\mathcal{O}_{ud}^{(8)}$
$\mathcal{W} \sim (1, 3)_0$	$\mathbf{8}_q$	$-(g_\mathcal{W}^q)^2/(48M_\mathcal{W}^2)$	$3\mathcal{O}_{qq}^{(3)E} - \mathcal{O}_{qq}^{(3)D}$
	$\mathbf{8}_\ell$	$(g_\mathcal{W}^\ell)^2/(48M_\mathcal{W}^2)$	$5\mathcal{O}_{\ell\ell}^E - 7\mathcal{O}_{\ell\ell}^D$
$\mathcal{L}_3 \sim (1, 2)_{-\frac{3}{2}}$	$(\mathbf{3}_e, \mathbf{3}_\ell)$	$ g_{\mathcal{L}_3} ^2/M_{\mathcal{L}_3}^2$	$\mathcal{O}_{\ell e}$
$\mathcal{U}_2 \sim (3, 1)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_d)$	$- g_{\mathcal{U}_2}^{ed} ^2/M_{\mathcal{U}_2}^2$	\mathcal{O}_{ed}
	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{U}_2}^{\ell q} ^2/(2M_{\mathcal{U}_2}^2)$	$\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{U}_5 \sim (3, 1)_{\frac{5}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_u)$	$- g_{\mathcal{U}_5} ^2/M_{\mathcal{U}_5}^2$	\mathcal{O}_{eu}
$\mathcal{Q}_1 \sim (3, 2)_{\frac{1}{6}}$	$(\mathbf{3}_u, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_1}^{\ell\ell} ^2/M_{\mathcal{Q}_1}^2$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_1}^{dq} ^2/(3M_{\mathcal{Q}_1}^2)$	$\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Q}_5 \sim (3, 2)_{-\frac{5}{6}}$	$(\mathbf{3}_d, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_5}^{d\ell} ^2/M_{\mathcal{Q}_5}^2$	$\mathcal{O}_{\ell d}$
	$(\mathbf{3}_e, \mathbf{3}_q)$	$ g_{\mathcal{Q}_5}^{eq} ^2/M_{\mathcal{Q}_5}^2$	\mathcal{O}_{qe}
	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_5}^{uq} ^2/(3M_{\mathcal{Q}_5}^2)$	$\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{X} \sim (3, 3)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_\mathcal{X} ^2/(8M_\mathcal{X}^2)$	$3\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{Y}_1 \sim (\bar{\mathbf{6}}, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_1} ^2/(3M_{\mathcal{Y}_1}^2)$	$2\mathcal{O}_{qd}^{(1)} + 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Y}_5 \sim (\bar{\mathbf{6}}, 2)_{-\frac{5}{6}}$	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_5} ^2/(3M_{\mathcal{Y}_5}^2)$	$2\mathcal{O}_{qu}^{(1)} + 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{G} \sim (8, 1)_0$	$\mathbf{8}_q$	$-(g_\mathcal{G}^q)^2/(144M_\mathcal{G}^2)$	$11\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} + 9\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$
	$\mathbf{8}_u$	$(g_\mathcal{G}^u)^2/(36M_\mathcal{G}^2)$	$3\mathcal{O}_{uu}^E - 5\mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$(g_\mathcal{G}^d)^2/(36M_\mathcal{G}^2)$	$3\mathcal{O}_{dd}^E - 5\mathcal{O}_{dd}^D$
$\mathcal{G}_1 \sim (8, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$ g_{\mathcal{G}_1} ^2/(9M_{\mathcal{G}_1}^2)$	$-4\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
$\mathcal{H} \sim (8, 3)_0$	$\mathbf{8}_q$	$-(g_\mathcal{H})^2/(576M_\mathcal{H}^2)$	$27\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} - 7\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$

Field	Irrep	Normalization	Operator
$N \sim (1, 1)_0$	$\mathbf{3}_\ell$	$ \lambda_N ^2/(4M_N^2)$	$\mathcal{O}_{\phi\ell}^{(1)} - \mathcal{O}_{\phi\ell}^{(3)}$
$E \sim (1, 1)_{-1}$	$\mathbf{3}_\ell$	$- \lambda_E ^2/(4M_E^2)$	$\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} - [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_1 \sim (1, 2)_{-\frac{1}{2}}$	$\mathbf{3}_e$	$ \lambda_{\Delta_1} ^2/(2M_{\Delta_1}^2)$	$\mathcal{O}_{\phi e} + [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_3 \sim (1, 2)_{-\frac{3}{2}}$	$\mathbf{3}_e$	$- \lambda_{\Delta_3} ^2/(2M_{\Delta_3}^2)$	$\mathcal{O}_{\phi e} - [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma \sim (1, 3)_0$	$\mathbf{3}_\ell$	$ \lambda_\Sigma ^2/(16M_\Sigma^2)$	$3\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} + [4y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma_1 \sim (1, 3)_{-1}$	$\mathbf{3}_\ell$	$ \lambda_{\Sigma_1} ^2/(16M_{\Sigma_1}^2)$	$\mathcal{O}_{\phi\ell}^{(3)} - 3\mathcal{O}_{\phi\ell}^{(1)} + [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$U \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_U ^2/(4M_U^2)$	$\mathcal{O}_{\phi q}^{(1)} - \mathcal{O}_{\phi q}^{(3)} + [2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$D \sim (3, 1)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$- \lambda_D ^2/(4M_D^2)$	$\mathcal{O}_{\phi q}^{(1)} + \mathcal{O}_{\phi q}^{(3)} - [2y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_1 \sim (3, 2)_{\frac{1}{6}}$	$\mathbf{3}_u$	$- \lambda_{Q_1}^u ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi u} - [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
	$\mathbf{3}_d$	$ \lambda_{Q_1}^d ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi d} + [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_5 \sim (3, 2)_{-\frac{5}{6}}$	$\mathbf{3}_d$	$- \lambda_{Q_5} ^2/(2M_{Q_5}^2)$	$\mathcal{O}_{\phi d} - [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_7 \sim (3, 2)_{\frac{7}{6}}$	$\mathbf{3}_u$	$ \lambda_{Q_7} ^2/(2M_{Q_7}^2)$	$\mathcal{O}_{\phi u} + [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_1 \sim (3, 3)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_1} ^2/(16M_{T_1}^2)$	$\mathcal{O}_{\phi q}^{(3)} - 3\mathcal{O}_{\phi q}^{(1)} + [2y_d^* \mathcal{O}_{d\phi} + 4y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_2 \sim (3, 3)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_2} ^2/(16M_{T_2}^2)$	$\mathcal{O}_{\phi q}^{(3)} + 3\mathcal{O}_{\phi q}^{(1)} + [4y_d^* \mathcal{O}_{d\phi} + 2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$

Leading directions

- Classification of all NP mediators
- Most flavor irreps match onto a single well-defined linear combination of dimension-6 SMEFT operators
- These linear combinations are denoted as leading SMEFT directions
- Suitable for phenomenological analysis

Field	Irrep	Normalization	Operator
$\mathcal{S}_1 \sim (1, 1)_1$	$\mathbf{3}_\ell$	$ y_{\mathcal{S}_1} ^2/M_{\mathcal{S}_1}^2$	$\mathcal{O}_{\ell\ell}^D - \mathcal{O}_{\ell\ell}^E$
$\mathcal{S}_2 \sim (1, 1)_2$	$\bar{\mathbf{6}}_e$	$ y_{\mathcal{S}_2} ^2/(2M_{\mathcal{S}_2}^2)$	\mathcal{O}_{ee}
	$(\bar{\mathbf{3}}_e, \mathbf{3}_\ell)$	$- y_\varphi^e ^2/(2M_\varphi^2)$	$\mathcal{O}_{\ell e}$
$\varphi \sim (1, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\varphi^d ^2/(6M_\varphi^2)$	$\mathcal{O}_{qd}^{(1)} + 6\mathcal{O}_{qd}^{(8)}$
	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\varphi^u ^2/(6M_\varphi^2)$	$\mathcal{O}_{qu}^{(1)} + 6\mathcal{O}_{qu}^{(8)}$
$\Xi_1 \sim (1, 3)_1$	$\bar{\mathbf{6}}_\ell$	$ y_{\Xi_1} ^2/(2M_{\Xi_1}^2)$	$\mathcal{O}_{\ell\ell}^D + \mathcal{O}_{\ell\ell}^E$
	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_{\omega_1}^{\ell\ell} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
	$(\mathbf{3}_e, \mathbf{3}_u)$	$ y_{\omega_1}^{eu} ^2/(2M_{\omega_1}^2)$	\mathcal{O}_{eu}
$\omega_1 \sim (3, 1)_{-\frac{1}{3}}$	$\bar{\mathbf{6}}_q$	$ y_{\omega_1}^{qq} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} + \mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_u)$	$ y_{\omega_1}^{du} ^2/(3M_{\omega_1}^2)$	$\mathcal{O}_{ud}^{(1)} - 3\mathcal{O}_{ud}^{(8)}$
$\omega_2 \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_d$	$ y_{\omega_2} ^2/M_{\omega_2}^2$	$\mathcal{O}_{dd}^D - \mathcal{O}_{dd}^E$
$\omega_4 \sim (3, 1)_{-\frac{4}{3}}$	$(\mathbf{3}_e, \mathbf{3}_d)$	$ y_{\omega_4}^{ed} ^2/(2M_{\omega_4}^2)$	\mathcal{O}_{ed}
	$\mathbf{3}_u$	$ y_{\omega_4}^{uu} ^2/M_{\omega_4}^2$	$\mathcal{O}_{uu}^D - \mathcal{O}_{uu}^E$
$\Pi_1 \sim (3, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_d)$	$- y_{\Pi_1} ^2/(2M_{\Pi_1}^2)$	$\mathcal{O}_{\ell d}$
$\Pi_7 \sim (3, 2)_{\frac{7}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_u)$	$- y_{\Pi_7}^{\ell u} ^2/(2M_{\Pi_7}^2)$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_e, \mathbf{3}_q)$	$- y_{\Pi_7}^{qe} ^2/(2M_{\Pi_7}^2)$	\mathcal{O}_{qe}
$\zeta \sim (3, 3)_{-\frac{1}{3}}$	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_\zeta^{\ell\ell} ^2/(4M_\zeta^2)$	$3\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
	$\mathbf{3}_q$	$ y_\zeta^{qq} ^2/(2M_\zeta^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
$\Omega_1 \sim (6, 1)_{\frac{1}{3}}$	$(\mathbf{3}_u, \mathbf{3}_d)$	$ y_{\Omega_1}^{ud} ^2/(6M_{\Omega_1}^2)$	$2\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
	$\bar{\mathbf{3}}_q$	$ y_{\Omega_1}^{qq} ^2/(4M_{\Omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} - \mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Omega_2 \sim (6, 1)_{-\frac{2}{3}}$	$\mathbf{6}_d$	$ y_{\Omega_2} ^2/(4M_{\Omega_2}^2)$	$\mathcal{O}_{dd}^D + \mathcal{O}_{dd}^E$
$\Omega_4 \sim (6, 1)_{\frac{4}{3}}$	$\mathbf{6}_u$	$ y_{\Omega_4} ^2/(4M_{\Omega_4}^2)$	$\mathcal{O}_{uu}^D + \mathcal{O}_{uu}^E$
$\Upsilon \sim (6, 3)_{\frac{1}{3}}$	$\mathbf{6}_q$	$ y_\Upsilon ^2/(8M_\Upsilon^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} + 3\mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Phi \sim (8, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\Phi^{qu} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\Phi^{dq} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$

Field	Irrep	Normalization	Operator
	$\mathbf{8}_\ell$	$-(g_\mathcal{B}^\ell)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{\ell\ell}^E - \mathcal{O}_{\ell\ell}^D$
	$\mathbf{8}_e$	$-(g_\mathcal{B}^e)^2/(6M_\mathcal{B}^2)$	\mathcal{O}_{ee}
$\mathcal{B} \sim (1, 1)_0$	$\mathbf{8}_q$	$-(g_\mathcal{B}^q)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(1)D}$
	$\mathbf{8}_u$	$-(g_\mathcal{B}^u)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{uu}^E - \mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$-(g_\mathcal{B}^d)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{dd}^E - \mathcal{O}_{dd}^D$
$\mathcal{B}_1 \sim (1, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$- g_{\mathcal{B}_1}^{du} ^2/(3M_{\mathcal{B}_1}^2)$	$\mathcal{O}_{ud}^{(1)} + 6\mathcal{O}_{ud}^{(8)}$
$\mathcal{W} \sim (1, 3)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{W}}^q)^2/(48M_{\mathcal{W}}^2)$	$3\mathcal{O}_{qq}^{(3)E} - \mathcal{O}_{qq}^{(3)D}$
	$\mathbf{8}_\ell$	$(g_{\mathcal{W}}^\ell)^2/(48M_{\mathcal{W}}^2)$	$5\mathcal{O}_{\ell\ell}^E - 7\mathcal{O}_{\ell\ell}^D$
$\mathcal{L}_3 \sim (1, 2)_{-\frac{3}{2}}$	$(\mathbf{3}_e, \mathbf{3}_\ell)$	$ g_{\mathcal{L}_3} ^2/M_{\mathcal{L}_3}^2$	$\mathcal{O}_{\ell e}$
$\mathcal{U}_2 \sim (3, 1)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_d)$	$- g_{\mathcal{U}_2}^{ed} ^2/M_{\mathcal{U}_2}^2$	\mathcal{O}_{ed}
	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{U}_2}^{\ell q} ^2/(2M_{\mathcal{U}_2}^2)$	$\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{U}_5 \sim (3, 1)_{\frac{5}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_u)$	$- g_{\mathcal{U}_5} ^2/M_{\mathcal{U}_5}^2$	\mathcal{O}_{eu}
$\mathcal{Q}_1 \sim (3, 2)_{\frac{1}{6}}$	$(\mathbf{3}_u, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_1}^{\ell\ell} ^2/M_{\mathcal{Q}_1}^2$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_1}^{dq} ^2/(3M_{\mathcal{Q}_1}^2)$	$\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$
	$(\mathbf{3}_d, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_5}^{d\ell} ^2/M_{\mathcal{Q}_5}^2$	$\mathcal{O}_{\ell d}$
$\mathcal{Q}_5 \sim (3, 2)_{-\frac{5}{6}}$	$(\mathbf{3}_e, \mathbf{3}_q)$	$ g_{\mathcal{Q}_5}^{eq} ^2/M_{\mathcal{Q}_5}^2$	\mathcal{O}_{qe}
	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_5}^{uq} ^2/(3M_{\mathcal{Q}_5}^2)$	$\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{X} \sim (3, 3)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{X}} ^2/(8M_{\mathcal{X}}^2)$	$3\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{Y}_1 \sim (\bar{6}, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_1} ^2/(3M_{\mathcal{Y}_1}^2)$	$2\mathcal{O}_{qd}^{(1)} + 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Y}_5 \sim (\bar{6}, 2)_{-\frac{5}{6}}$	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_5} ^2/(3M_{\mathcal{Y}_5}^2)$	$2\mathcal{O}_{qu}^{(1)} + 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{G} \sim (8, 1)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{G}}^q)^2/(144M_{\mathcal{G}}^2)$	$11\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} + 9\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$
	$\mathbf{8}_u$	$(g_{\mathcal{G}}^u)^2/(36M_{\mathcal{G}}^2)$	$3\mathcal{O}_{uu}^E - 5\mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$(g_{\mathcal{G}}^d)^2/(36M_{\mathcal{G}}^2)$	$3\mathcal{O}_{dd}^E - 5\mathcal{O}_{dd}^D$
$\mathcal{G}_1 \sim (8, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$ g_{\mathcal{G}_1} ^2/(9M_{\mathcal{G}_1}^2)$	$-4\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
$\mathcal{H} \sim (8, 3)_0$	$\mathbf{8}_q$	$-(g_{\mathcal{H}})^2/(576M_{\mathcal{H}}^2)$	$27\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} - 7\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$

Field	Irrep	Normalization	Operator
$N \sim (1, 1)_0$	$\mathbf{3}_\ell$	$ \lambda_N ^2/(4M_N^2)$	$\mathcal{O}_{\phi\ell}^{(1)} - \mathcal{O}_{\phi\ell}^{(3)}$
$E \sim (1, 1)_{-1}$	$\mathbf{3}_\ell$	$- \lambda_E ^2/(4M_E^2)$	$\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} - [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_1 \sim (1, 2)_{-\frac{1}{2}}$	$\mathbf{3}_e$	$ \lambda_{\Delta_1} ^2/(2M_{\Delta_1}^2)$	$\mathcal{O}_{\phi e} + [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_3 \sim (1, 2)_{-\frac{3}{2}}$	$\mathbf{3}_e$	$- \lambda_{\Delta_3} ^2/(2M_{\Delta_3}^2)$	$\mathcal{O}_{\phi e} - [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma \sim (1, 3)_0$	$\mathbf{3}_\ell$	$ \lambda_\Sigma ^2/(16M_\Sigma^2)$	$3\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} + [4y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma_1 \sim (1, 3)_{-1}$	$\mathbf{3}_\ell$	$ \lambda_{\Sigma_1} ^2/(16M_{\Sigma_1}^2)$	$\mathcal{O}_{\phi\ell}^{(3)} - 3\mathcal{O}_{\phi\ell}^{(1)} + [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$U \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_U ^2/(4M_U^2)$	$\mathcal{O}_{\phi q}^{(1)} - \mathcal{O}_{\phi q}^{(3)} + [2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$D \sim (3, 1)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$- \lambda_D ^2/(4M_D^2)$	$\mathcal{O}_{\phi q}^{(1)} + \mathcal{O}_{\phi q}^{(3)} - [2y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
	$\mathbf{3}_u$	$- \lambda_{Q_1}^u ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi u} - [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$Q_1 \sim (3, 2)_{\frac{1}{6}}$	$\mathbf{3}_d$	$ \lambda_{Q_1}^d ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi d} + [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_5 \sim (3, 2)_{-\frac{5}{6}}$	$\mathbf{3}_d$	$- \lambda_{Q_5} ^2/(2M_{Q_5}^2)$	$\mathcal{O}_{\phi d} - [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_7 \sim (3, 2)_{\frac{7}{6}}$	$\mathbf{3}_u$	$ \lambda_{Q_7} ^2/(2M_{Q_7}^2)$	$\mathcal{O}_{\phi u} + [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_1 \sim (3, 3)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_1} ^2/(16M_{T_1}^2)$	$\mathcal{O}_{\phi q}^{(3)} - 3\mathcal{O}_{\phi q}^{(1)} + [2y_d^* \mathcal{O}_{d\phi} + 4y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_2 \sim (3, 3)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_2} ^2/(16M_{T_2}^2)$	$\mathcal{O}_{\phi q}^{(3)} + 3\mathcal{O}_{\phi q}^{(1)} + [4y_d^* \mathcal{O}_{d\phi} + 2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$

Leading directions

- Classification of all NP mediators
- Most flavor irreps match onto a single well-defined linear combination of dimension-6 SMEFT operators
- These linear combinations are denoted as leading SMEFT directions
- Suitable for phenomenological analysis
- Main goal: estimate the lower bound on the mass scale for different irreps

Field	Irrep	Normalization	Operator
$\mathcal{S}_1 \sim (1, 1)_1$	$\mathbf{3}_\ell$	$ y_{\mathcal{S}_1} ^2/M_{\mathcal{S}_1}^2$	$\mathcal{O}_{\ell\ell}^D - \mathcal{O}_{\ell\ell}^E$
$\mathcal{S}_2 \sim (1, 1)_2$	$\bar{\mathbf{6}}_e$	$ y_{\mathcal{S}_2} ^2/(2M_{\mathcal{S}_2}^2)$	\mathcal{O}_{ee}
	$(\bar{\mathbf{3}}_e, \mathbf{3}_\ell)$	$- y_\varphi^e ^2/(2M_\varphi^2)$	$\mathcal{O}_{\ell e}$
$\varphi \sim (1, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\varphi^d ^2/(6M_\varphi^2)$	$\mathcal{O}_{qd}^{(1)} + 6\mathcal{O}_{qd}^{(8)}$
	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\varphi^u ^2/(6M_\varphi^2)$	$\mathcal{O}_{qu}^{(1)} + 6\mathcal{O}_{qu}^{(8)}$
$\Xi_1 \sim (1, 3)_1$	$\bar{\mathbf{6}}_\ell$	$ y_{\Xi_1} ^2/(2M_{\Xi_1}^2)$	$\mathcal{O}_{\ell\ell}^D + \mathcal{O}_{\ell\ell}^E$
	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_{\omega_1}^{\ell\ell} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
	$(\mathbf{3}_e, \mathbf{3}_u)$	$ y_{\omega_1}^{eu} ^2/(2M_{\omega_1}^2)$	\mathcal{O}_{eu}
$\omega_1 \sim (3, 1)_{-\frac{1}{3}}$	$\bar{\mathbf{6}}_q$	$ y_{\omega_1}^{qq} ^2/(4M_{\omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} + \mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_u)$	$ y_{\omega_1}^{du} ^2/(3M_{\omega_1}^2)$	$\mathcal{O}_{ud}^{(1)} - 3\mathcal{O}_{ud}^{(8)}$
$\omega_2 \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_d$	$ y_{\omega_2} ^2/M_{\omega_2}^2$	$\mathcal{O}_{dd}^D - \mathcal{O}_{dd}^E$
$\omega_4 \sim (3, 1)_{-\frac{4}{3}}$	$(\mathbf{3}_e, \mathbf{3}_d)$	$ y_{\omega_4}^{ed} ^2/(2M_{\omega_4}^2)$	\mathcal{O}_{ed}
	$\mathbf{3}_u$	$ y_{\omega_4}^{uu} ^2/M_{\omega_4}^2$	$\mathcal{O}_{uu}^D - \mathcal{O}_{uu}^E$
$\Pi_1 \sim (3, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_d)$	$- y_{\Pi_1} ^2/(2M_{\Pi_1}^2)$	$\mathcal{O}_{\ell d}$
$\Pi_7 \sim (3, 2)_{\frac{7}{6}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_u)$	$- y_{\Pi_7}^{\ell u} ^2/(2M_{\Pi_7}^2)$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_e, \mathbf{3}_q)$	$- y_{\Pi_7}^{qe} ^2/(2M_{\Pi_7}^2)$	\mathcal{O}_{qe}
$\zeta \sim (3, 3)_{-\frac{1}{3}}$	$(\mathbf{3}_q, \mathbf{3}_\ell)$	$ y_\zeta^{\ell\ell} ^2/(4M_\zeta^2)$	$3\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
	$\mathbf{3}_q$	$ y_\zeta^{qq} ^2/(2M_\zeta^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(3)E}$
$\Omega_1 \sim (6, 1)_{\frac{1}{3}}$	$(\mathbf{3}_u, \mathbf{3}_d)$	$ y_{\Omega_1}^{ud} ^2/(6M_{\Omega_1}^2)$	$2\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
	$\bar{\mathbf{3}}_q$	$ y_{\Omega_1}^{qq} ^2/(4M_{\Omega_1}^2)$	$\mathcal{O}_{qq}^{(1)D} - \mathcal{O}_{qq}^{(3)D} - \mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Omega_2 \sim (6, 1)_{-\frac{2}{3}}$	$\mathbf{6}_d$	$ y_{\Omega_2} ^2/(4M_{\Omega_2}^2)$	$\mathcal{O}_{dd}^D + \mathcal{O}_{dd}^E$
$\Omega_4 \sim (6, 1)_{\frac{4}{3}}$	$\mathbf{6}_u$	$ y_{\Omega_4} ^2/(4M_{\Omega_4}^2)$	$\mathcal{O}_{uu}^D + \mathcal{O}_{uu}^E$
$\Upsilon \sim (6, 3)_{\frac{1}{3}}$	$\mathbf{6}_q$	$ y_\Upsilon ^2/(8M_\Upsilon^2)$	$3\mathcal{O}_{qq}^{(1)D} + \mathcal{O}_{qq}^{(3)D} + 3\mathcal{O}_{qq}^{(1)E} + \mathcal{O}_{qq}^{(3)E}$
$\Phi \sim (8, 2)_{\frac{1}{2}}$	$(\bar{\mathbf{3}}_q, \mathbf{3}_u)$	$- y_\Phi^{qu} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
	$(\bar{\mathbf{3}}_d, \mathbf{3}_q)$	$- y_\Phi^{dq} ^2/(18M_\Phi^2)$	$4\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$

Field	Irrep	Normalization	Operator
	$\mathbf{8}_\ell$	$-(g_\mathcal{B}^\ell)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{\ell\ell}^E - \mathcal{O}_{\ell\ell}^D$
	$\mathbf{8}_e$	$-(g_\mathcal{B}^e)^2/(6M_\mathcal{B}^2)$	\mathcal{O}_{ee}
$\mathcal{B} \sim (1, 1)_0$	$\mathbf{8}_q$	$-(g_\mathcal{B}^q)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{qq}^{(1)E} - \mathcal{O}_{qq}^{(1)D}$
	$\mathbf{8}_u$	$-(g_\mathcal{B}^u)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{uu}^E - \mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$-(g_\mathcal{B}^d)^2/(12M_\mathcal{B}^2)$	$3\mathcal{O}_{dd}^E - \mathcal{O}_{dd}^D$
$\mathcal{B}_1 \sim (1, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$- g_{\mathcal{B}_1}^{du} ^2/(3M_{\mathcal{B}_1}^2)$	$\mathcal{O}_{ud}^{(1)} + 6\mathcal{O}_{ud}^{(8)}$
$\mathcal{W} \sim (1, 3)_0$	$\mathbf{8}_q$	$-(g_\mathcal{W}^q)^2/(48M_\mathcal{W}^2)$	$3\mathcal{O}_{qq}^{(3)E} - \mathcal{O}_{qq}^{(3)D}$
	$\mathbf{8}_\ell$	$(g_\mathcal{W}^\ell)^2/(48M_\mathcal{W}^2)$	$5\mathcal{O}_{\ell\ell}^E - 7\mathcal{O}_{\ell\ell}^D$
$\mathcal{L}_3 \sim (1, 2)_{-\frac{3}{2}}$	$(\mathbf{3}_e, \mathbf{3}_\ell)$	$ g_{\mathcal{L}_3} ^2/M_{\mathcal{L}_3}^2$	$\mathcal{O}_{\ell e}$
$\mathcal{U}_2 \sim (3, 1)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_d)$	$- g_{\mathcal{U}_2}^{ed} ^2/M_{\mathcal{U}_2}^2$	\mathcal{O}_{ed}
	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_{\mathcal{U}_2}^{\ell q} ^2/(2M_{\mathcal{U}_2}^2)$	$\mathcal{O}_{\ell q}^{(1)} + \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{U}_5 \sim (3, 1)_{\frac{5}{3}}$	$(\bar{\mathbf{3}}_e, \mathbf{3}_u)$	$- g_{\mathcal{U}_5} ^2/M_{\mathcal{U}_5}^2$	\mathcal{O}_{eu}
$\mathcal{Q}_1 \sim (3, 2)_{\frac{1}{6}}$	$(\mathbf{3}_u, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_1}^{\ell\ell} ^2/M_{\mathcal{Q}_1}^2$	$\mathcal{O}_{\ell u}$
	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_1}^{dq} ^2/(3M_{\mathcal{Q}_1}^2)$	$\mathcal{O}_{qd}^{(1)} - 3\mathcal{O}_{qd}^{(8)}$
	$(\mathbf{3}_d, \mathbf{3}_\ell)$	$ g_{\mathcal{Q}_5}^{d\ell} ^2/M_{\mathcal{Q}_5}^2$	$\mathcal{O}_{\ell d}$
$\mathcal{Q}_5 \sim (3, 2)_{-\frac{5}{6}}$	$(\mathbf{3}_e, \mathbf{3}_q)$	$ g_{\mathcal{Q}_5}^{eq} ^2/M_{\mathcal{Q}_5}^2$	\mathcal{O}_{qe}
	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$2 g_{\mathcal{Q}_5}^{uq} ^2/(3M_{\mathcal{Q}_5}^2)$	$\mathcal{O}_{qu}^{(1)} - 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{X} \sim (3, 3)_{\frac{2}{3}}$	$(\bar{\mathbf{3}}_\ell, \mathbf{3}_q)$	$- g_\mathcal{X} ^2/(8M_\mathcal{X}^2)$	$3\mathcal{O}_{\ell q}^{(1)} - \mathcal{O}_{\ell q}^{(3)}$
$\mathcal{Y}_1 \sim (\bar{\mathbf{6}}, 2)_{\frac{1}{6}}$	$(\bar{\mathbf{3}}_d, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_1} ^2/(3M_{\mathcal{Y}_1}^2)$	$2\mathcal{O}_{qd}^{(1)} + 3\mathcal{O}_{qd}^{(8)}$
$\mathcal{Y}_5 \sim (\bar{\mathbf{6}}, 2)_{-\frac{5}{6}}$	$(\bar{\mathbf{3}}_u, \bar{\mathbf{3}}_q)$	$ g_{\mathcal{Y}_5} ^2/(3M_{\mathcal{Y}_5}^2)$	$2\mathcal{O}_{qu}^{(1)} + 3\mathcal{O}_{qu}^{(8)}$
$\mathcal{G} \sim (8, 1)_0$	$\mathbf{8}_q$	$-(g_\mathcal{G}^q)^2/(144M_\mathcal{G}^2)$	$11\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} + 9\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$
	$\mathbf{8}_u$	$(g_\mathcal{G}^u)^2/(36M_\mathcal{G}^2)$	$3\mathcal{O}_{uu}^E - 5\mathcal{O}_{uu}^D$
	$\mathbf{8}_d$	$(g_\mathcal{G}^d)^2/(36M_\mathcal{G}^2)$	$3\mathcal{O}_{dd}^E - 5\mathcal{O}_{dd}^D$
$\mathcal{G}_1 \sim (8, 1)_1$	$(\bar{\mathbf{3}}_d, \mathbf{3}_u)$	$ g_{\mathcal{G}_1} ^2/(9M_{\mathcal{G}_1}^2)$	$-4\mathcal{O}_{ud}^{(1)} + 3\mathcal{O}_{ud}^{(8)}$
$\mathcal{H} \sim (8, 3)_0$	$\mathbf{8}_q$	$-(g_\mathcal{H})^2/(576M_\mathcal{H}^2)$	$27\mathcal{O}_{qq}^{(1)D} - 9\mathcal{O}_{qq}^{(1)E} - 7\mathcal{O}_{qq}^{(3)D} - 3\mathcal{O}_{qq}^{(3)E}$

Field	Irrep	Normalization	Operator
$N \sim (1, 1)_0$	$\mathbf{3}_\ell$	$ \lambda_N ^2/(4M_N^2)$	$\mathcal{O}_{\phi\ell}^{(1)} - \mathcal{O}_{\phi\ell}^{(3)}$
$E \sim (1, 1)_{-1}$	$\mathbf{3}_\ell$	$- \lambda_E ^2/(4M_E^2)$	$\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} - [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_1 \sim (1, 2)_{-\frac{1}{2}}$	$\mathbf{3}_e$	$ \lambda_{\Delta_1} ^2/(2M_{\Delta_1}^2)$	$\mathcal{O}_{\phi e} + [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Delta_3 \sim (1, 2)_{-\frac{3}{2}}$	$\mathbf{3}_e$	$- \lambda_{\Delta_3} ^2/(2M_{\Delta_3}^2)$	$\mathcal{O}_{\phi e} - [y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma \sim (1, 3)_0$	$\mathbf{3}_\ell$	$ \lambda_\Sigma ^2/(16M_\Sigma^2)$	$3\mathcal{O}_{\phi\ell}^{(1)} + \mathcal{O}_{\phi\ell}^{(3)} + [4y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$\Sigma_1 \sim (1, 3)_{-1}$	$\mathbf{3}_\ell$	$ \lambda_{\Sigma_1} ^2/(16M_{\Sigma_1}^2)$	$\mathcal{O}_{\phi\ell}^{(3)} - 3\mathcal{O}_{\phi\ell}^{(1)} + [2y_e^* \mathcal{O}_{e\phi} + \text{h.c.}]$
$U \sim (3, 1)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_U ^2/(4M_U^2)$	$\mathcal{O}_{\phi q}^{(1)} - \mathcal{O}_{\phi q}^{(3)} + [2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$D \sim (3, 1)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$- \lambda_D ^2/(4M_D^2)$	$\mathcal{O}_{\phi q}^{(1)} + \mathcal{O}_{\phi q}^{(3)} - [2y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
	$\mathbf{3}_u$	$- \lambda_{Q_1}^u ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi u} - [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$Q_1 \sim (3, 2)_{\frac{1}{6}}$	$\mathbf{3}_d$	$ \lambda_{Q_1}^d ^2/(2M_{Q_1}^2)$	$\mathcal{O}_{\phi d} + [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_5 \sim (3, 2)_{-\frac{5}{6}}$	$\mathbf{3}_d$	$- \lambda_{Q_5} ^2/(2M_{Q_5}^2)$	$\mathcal{O}_{\phi d} - [y_d^* \mathcal{O}_{d\phi} + \text{h.c.}]$
$Q_7 \sim (3, 2)_{\frac{7}{6}}$	$\mathbf{3}_u$	$ \lambda_{Q_7} ^2/(2M_{Q_7}^2)$	$\mathcal{O}_{\phi u} + [y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_1 \sim (3, 3)_{-\frac{1}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_1} ^2/(16M_{T_1}^2)$	$\mathcal{O}_{\phi q}^{(3)} - 3\mathcal{O}_{\phi q}^{(1)} + [2y_d^* \mathcal{O}_{d\phi} + 4y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$
$T_2 \sim (3, 3)_{\frac{2}{3}}$	$\mathbf{3}_q$	$ \lambda_{T_2} ^2/(16M_{T_2}^2)$	$\mathcal{O}_{\phi q}^{(3)} + 3\mathcal{O}_{\phi q}^{(1)} + [4y_d^* \mathcal{O}_{d\phi} + 2y_u^* \mathcal{O}_{u\phi} + \text{h.c.}]$

Leading directions: phenomenology

- All NP mediators can be classified into 5 phenomenological classes
- For each class the corresponding fit is employed

Leading directions: phenomenology

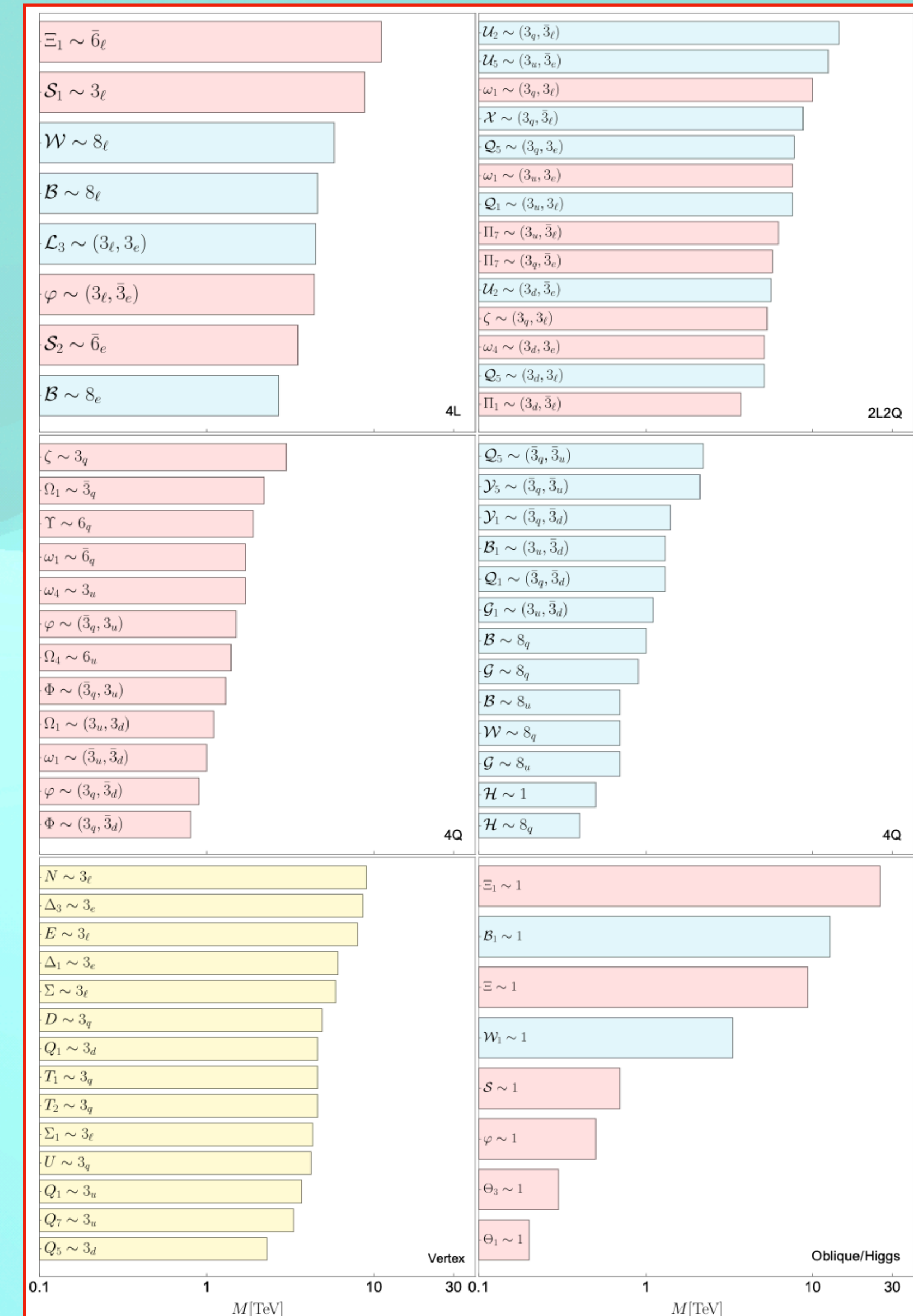
- All NP mediators can be classified into 5 phenomenological classes
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 - Class I: 4-lepton
 - Class II: 2-quark-2-lepton
 - Class III: 4-quark
 - Class IV: W/Z corrections
 - Class V: Higgs/oblique

Leading directions: phenomenology

Greljo, AP [2305.08898]

- All NP mediators can be classified into 5 phenomenological classes
- For each class the corresponding fit is employed

- Class I: 4-lepton
- Class II: 2-quark-2-lepton
- Class III: 4-quark
- Class IV: W/Z corrections
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Discrete leptonic directions

Discrete flavor symmetries

- Analysis of the $U(3)^5$ subgroups

\mathcal{L}_ψ $U(3)^5 = U(3)_q \times U(3)_u \times U(3)_d \times U(3)_\ell \times U(3)_e$

$\mathcal{L}_\psi^{(q)}$ $U(3)^3, U(2)^2 \times U(3)_d, U(2)^3 \times U(1)_{b_R}, U(2)^3$

$\mathcal{L}_\psi^{(\ell)}$ $U(3)^2, U(3)_V, U(2)_V, U(2)^2 \times U(1)^2, U(2)^2, U(1)^6, U(1)^3$

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Grzadkowski, Iskrzynski, Misiak, Rosiek [1008.4884]

Discrete flavor symmetries

- Analysis of the $U(3)^5$ subgroups

\mathcal{L}_ψ $U(3)^5 = U(3)_q \times U(3)_u \times U(3)_d \times U(3)_\ell \times U(3)_e$

$\mathcal{L}_\psi^{(q)}$ $U(3)^3, U(2)^2 \times U(3)_d, U(2)^3 \times U(1)_{b_R}, U(2)^3$

$\mathcal{L}_\psi^{(\ell)}$ $U(3)^2, U(3)_V, U(2)_V, U(2)^2 \times U(1)^2, U(2)^2, U(1)^6, U(1)^3$

What about discrete flavor symmetries?

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jkn} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Discrete flavor symmetries

- Analysis of the $U(3)^5$ subgroups

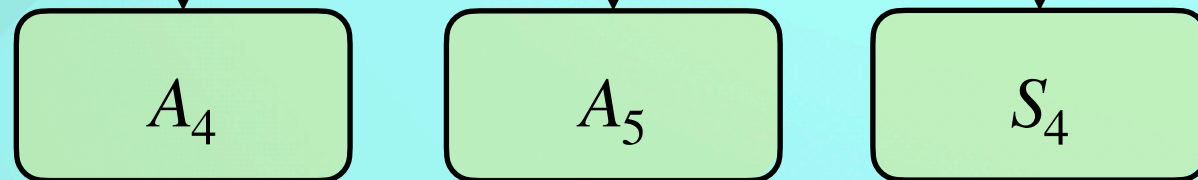
\mathcal{L}_ψ $U(3)^5 = U(3)_q \times U(3)_u \times U(3)_d \times U(3)_\ell \times U(3)_e$

$\mathcal{L}_\psi^{(q)}$ $U(3)^3, U(2)^2 \times U(3)_d, U(2)^3 \times U(1)_{b_R}, U(2)^3$

$\mathcal{L}_\psi^{(\ell)}$ $U(3)^2, U(3)_V, U(2)_V, U(2)^2 \times U(1)^2, U(2)^2, U(1)^6, U(1)^3$

- [0910.4389] [1306.1500] [1907.11714]
- [0807.3160] [1211.5143] [1811.10619]
- [1112.1959] [1004.0321] [2404.06520]
- [1101.2874] [1101.2874] [1904.03937]
- [1301.2963] [1301.2963] [1909.06520]

What about discrete flavor symmetries?



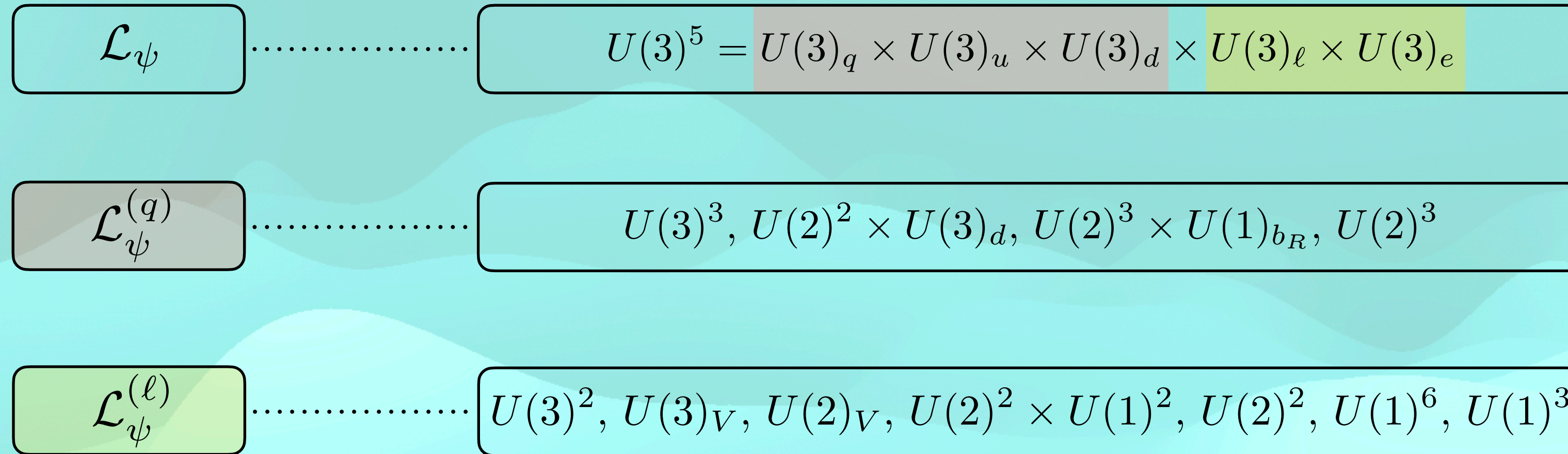
X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{W}B}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^{\alpha j})^T C q_r^{\beta k}] [(q_s^m)^T C l_t^n]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

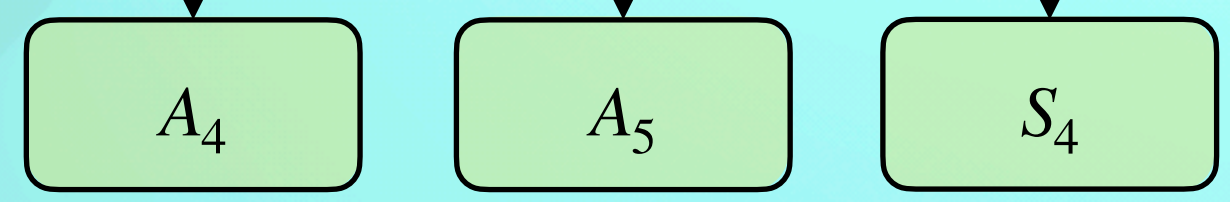
Grzadkowski, Iskrzynski, Misiak, Rosiek [1008.4884]

Discrete flavor symmetries

- Analysis of the $U(3)^5$ subgroups



What about discrete flavor symmetries?



- [0910.4389] [1306.1500] [1907.11714]
- [0807.3160] [1211.5143] [1811.10619]
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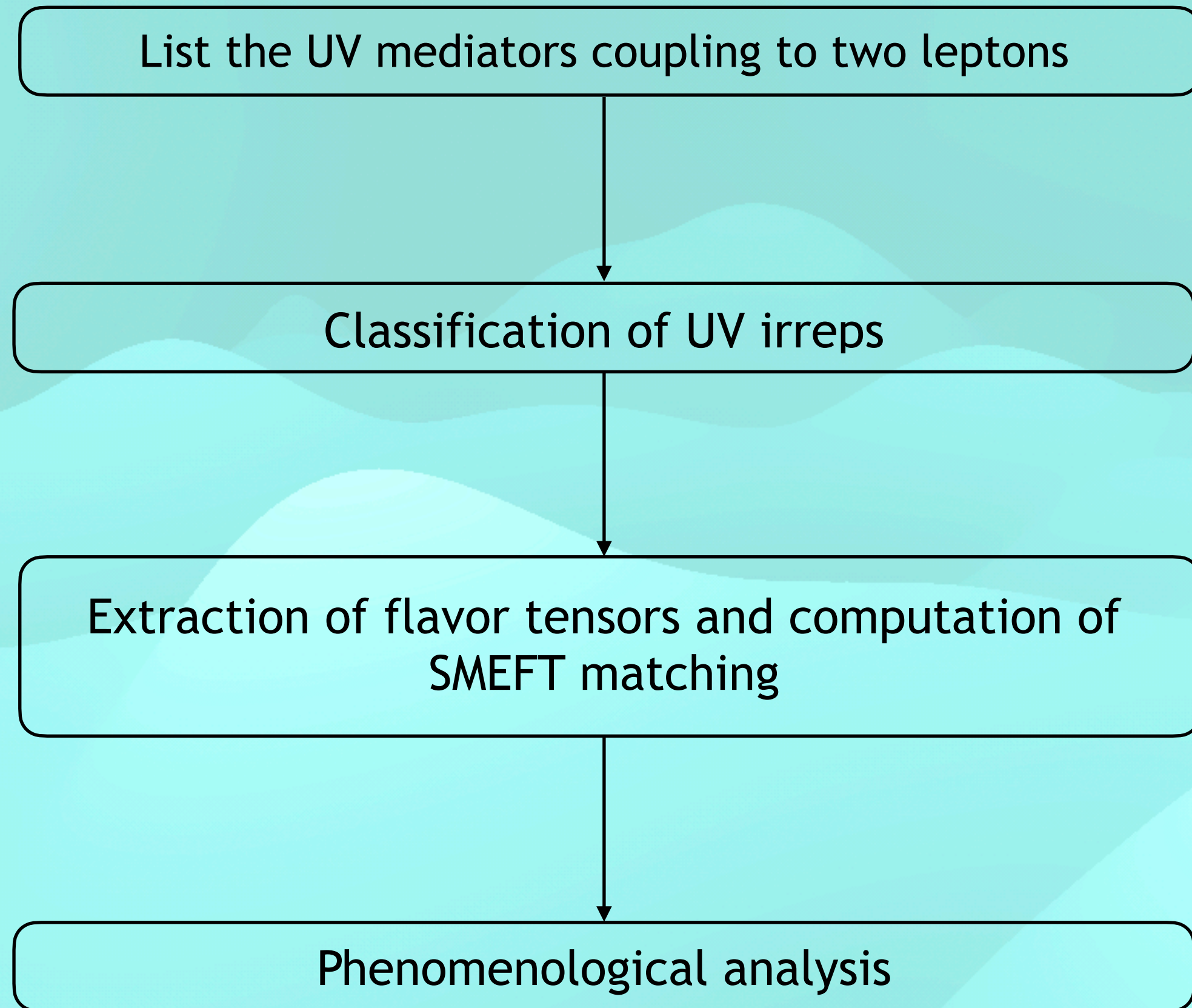
- Interplay of these symmetries and the UV mediators

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2 \varphi^3$	
Q_G	$f^{ABC} G_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger \varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger \varphi)(\bar{l}_p e_r \varphi)$
$Q_{\tilde{G}}$	$f^{ABC} \tilde{G}_\mu^{A\nu} G_\nu^{B\rho} G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger \varphi)\Box(\varphi^\dagger \varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p u_r \tilde{\varphi})$
Q_W	$\varepsilon^{IJK} W_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu \varphi)^* (\varphi^\dagger D_\mu \varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger \varphi)(\bar{q}_p d_r \varphi)$
$Q_{\tilde{W}}$	$\varepsilon^{IJK} \tilde{W}_\mu^{I\nu} W_\nu^{J\rho} W_\rho^{K\mu}$				
$X^2 \varphi^2$		$\psi^2 X \varphi$		$\psi^2 \varphi^2 D$	
$Q_{\varphi G}$	$\varphi^\dagger \varphi G_{\mu\nu}^A G^{A\mu\nu}$	Q_{eW}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{l}_p \gamma^\mu l_r)$
$Q_{\varphi \tilde{G}}$	$\varphi^\dagger \varphi \tilde{G}_{\mu\nu}^A G^{A\mu\nu}$	Q_{eB}	$(\bar{l}_p \sigma^{\mu\nu} e_r) \varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{l}_p \tau^I \gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger \varphi W_{\mu\nu}^I W^{I\mu\nu}$	Q_{uG}	$(\bar{q}_p \sigma^{\mu\nu} T^A u_r) \tilde{\varphi} G_{\mu\nu}^A$	$Q_{\varphi e}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{e}_p \gamma^\mu e_r)$
$Q_{\varphi \tilde{W}}$	$\varphi^\dagger \varphi \tilde{W}_{\mu\nu}^I W^{I\mu\nu}$	Q_{uW}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tau^I \tilde{\varphi} W_{\mu\nu}^I$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{q}_p \gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger \varphi B_{\mu\nu} B^{\mu\nu}$	Q_{uB}	$(\bar{q}_p \sigma^{\mu\nu} u_r) \tilde{\varphi} B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}_p \tau^I \gamma^\mu q_r)$
$Q_{\varphi \tilde{B}}$	$\varphi^\dagger \varphi \tilde{B}_{\mu\nu} B^{\mu\nu}$	Q_{dG}	$(\bar{q}_p \sigma^{\mu\nu} T^A d_r) \varphi G_{\mu\nu}^A$	$Q_{\varphi u}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}_p \gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger \tau^I \varphi W_{\mu\nu}^I B^{\mu\nu}$	Q_{dW}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \tau^I \varphi W_{\mu\nu}^I$	$Q_{\varphi d}$	$(\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{d}_p \gamma^\mu d_r)$
$Q_{\varphi \tilde{WB}}$	$\varphi^\dagger \tau^I \varphi \tilde{W}_{\mu\nu}^I B^{\mu\nu}$	Q_{dB}	$(\bar{q}_p \sigma^{\mu\nu} d_r) \varphi B_{\mu\nu}$	$Q_{\varphi ud}$	$i(\tilde{\varphi}^\dagger D_\mu \varphi)(\bar{u}_p \gamma^\mu d_r)$

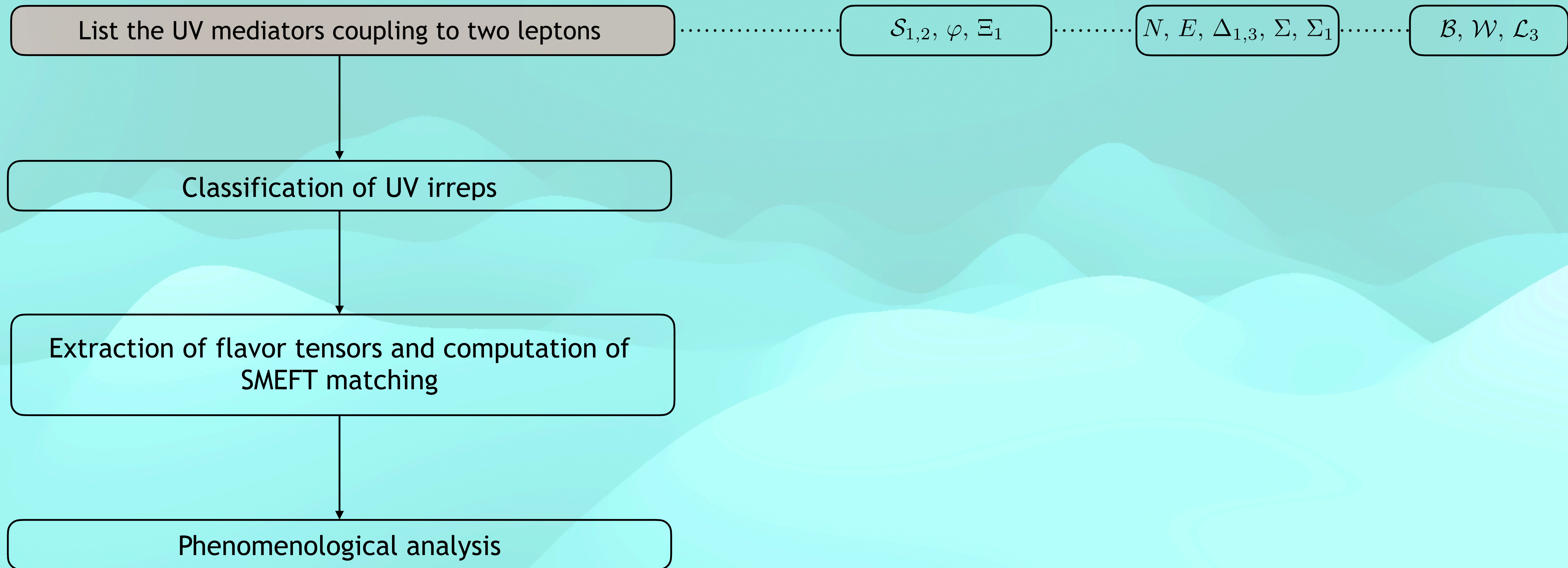
$(\bar{L}L)(\bar{L}L)$		$(\bar{R}R)(\bar{R}R)$		$(\bar{L}L)(\bar{R}R)$	
Q_{ll}	$(\bar{l}_p \gamma_\mu l_r)(\bar{l}_s \gamma^\mu l_t)$	Q_{ee}	$(\bar{e}_p \gamma_\mu e_r)(\bar{e}_s \gamma^\mu e_t)$	Q_{le}	$(\bar{l}_p \gamma_\mu l_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{qq}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{uu}	$(\bar{u}_p \gamma_\mu u_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{lu}	$(\bar{l}_p \gamma_\mu l_r)(\bar{u}_s \gamma^\mu u_t)$
$Q_{qq}^{(3)}$	$(\bar{q}_p \gamma_\mu \tau^I q_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{dd}	$(\bar{d}_p \gamma_\mu d_r)(\bar{d}_s \gamma^\mu d_t)$	Q_{ld}	$(\bar{l}_p \gamma_\mu l_r)(\bar{d}_s \gamma^\mu d_t)$
$Q_{lq}^{(1)}$	$(\bar{l}_p \gamma_\mu l_r)(\bar{q}_s \gamma^\mu q_t)$	Q_{eu}	$(\bar{e}_p \gamma_\mu e_r)(\bar{u}_s \gamma^\mu u_t)$	Q_{qe}	$(\bar{q}_p \gamma_\mu q_r)(\bar{e}_s \gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \tau^I l_r)(\bar{q}_s \gamma^\mu \tau^I q_t)$	Q_{ed}	$(\bar{e}_p \gamma_\mu e_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{u}_s \gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar{u}_p \gamma_\mu u_r)(\bar{d}_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{u}_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar{u}_p \gamma_\mu T^A u_r)(\bar{d}_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar{q}_p \gamma_\mu q_r)(\bar{d}_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar{q}_p \gamma_\mu T^A q_r)(\bar{d}_s \gamma^\mu T^A d_t)$
$(\bar{L}R)(\bar{R}L)$ and $(\bar{L}R)(\bar{L}R)$		B -violating			
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s^k q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(d_p^\alpha)^T C u_r^\beta] [(q_s^\gamma)^T C l_t^k]$		
$Q_{quqd}^{(1)}$	$(\bar{q}_p^j u_r) \varepsilon_{jk} (\bar{q}_s^k d_t)$	Q_{quu}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jk} [(q_p^\alpha)^T C q_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{quqd}^{(8)}$	$(\bar{q}_p^j T^A u_r) \varepsilon_{jk} (\bar{q}_s^k T^A d_t)$	Q_{quq}	$\varepsilon^{\alpha\beta\gamma} \varepsilon_{jnm} \varepsilon_{km} [(q_p^\alpha)^T C q_r^\beta] [(q_s^\gamma)^T C l_t^m]$		
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r) \varepsilon_{jk} (\bar{q}_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma} [(d_p^\alpha)^T C u_r^\beta] [(u_s^\gamma)^T C e_t]$		
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r) \varepsilon_{jk} (\bar{q}_s^k \sigma^{\mu\nu} u_t)$				

Grzadkowski, Iskrzynski, Misiak, Rosiek [1008.4884]

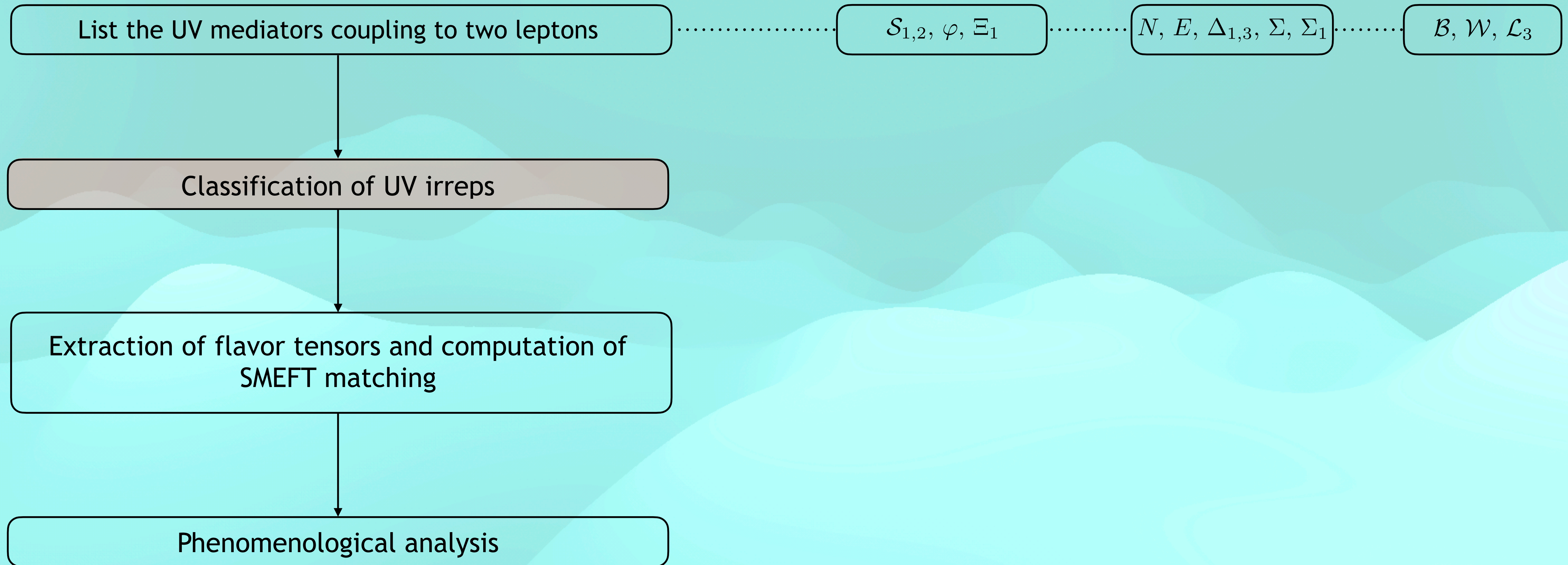
Procedure and example



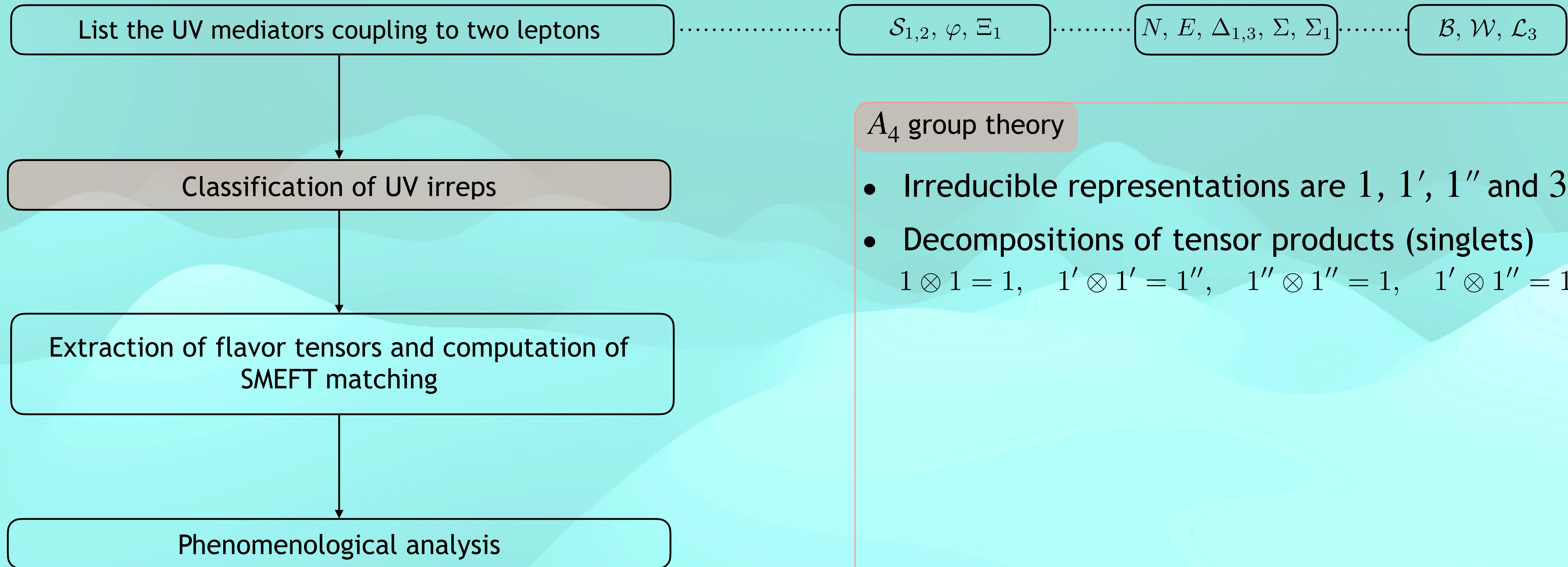
Procedure and example



Procedure and example



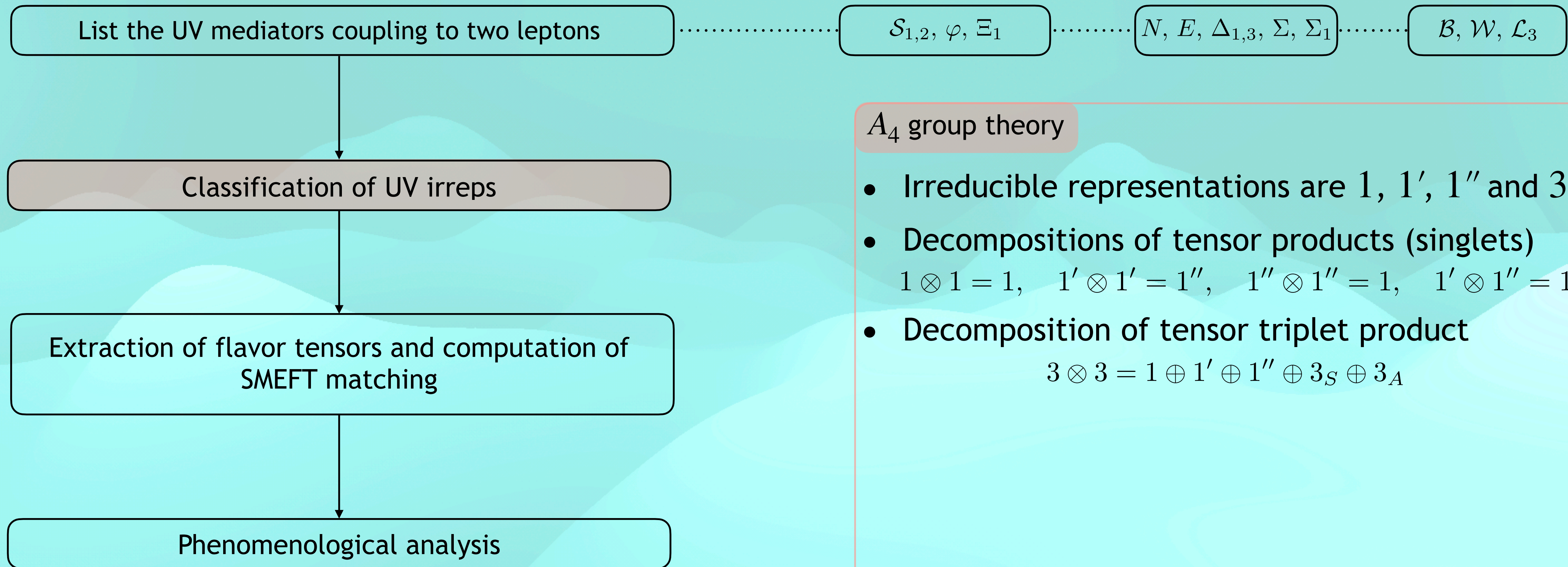
Procedure and example



A_4 group theory

- Irreducible representations are $1, 1', 1''$ and 3
- Decompositions of tensor products (singlets)
 $1 \otimes 1 = 1, \quad 1' \otimes 1' = 1'', \quad 1'' \otimes 1'' = 1, \quad 1' \otimes 1'' = 1$

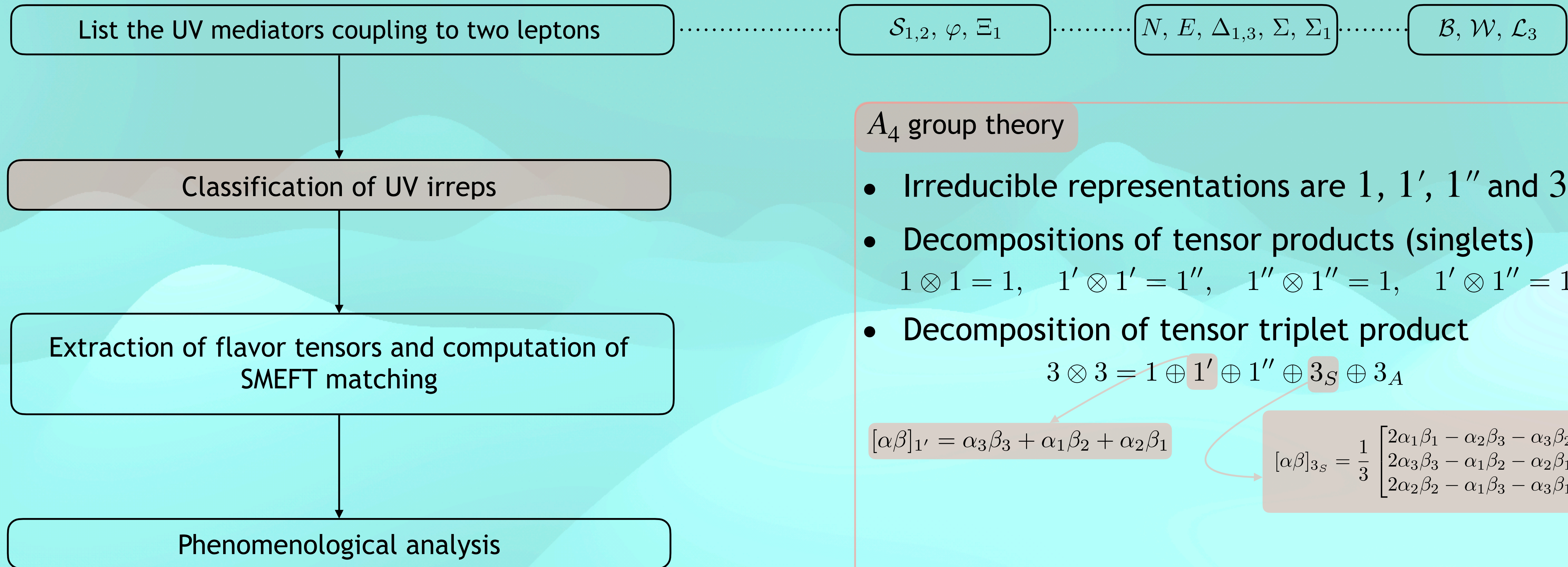
Procedure and example



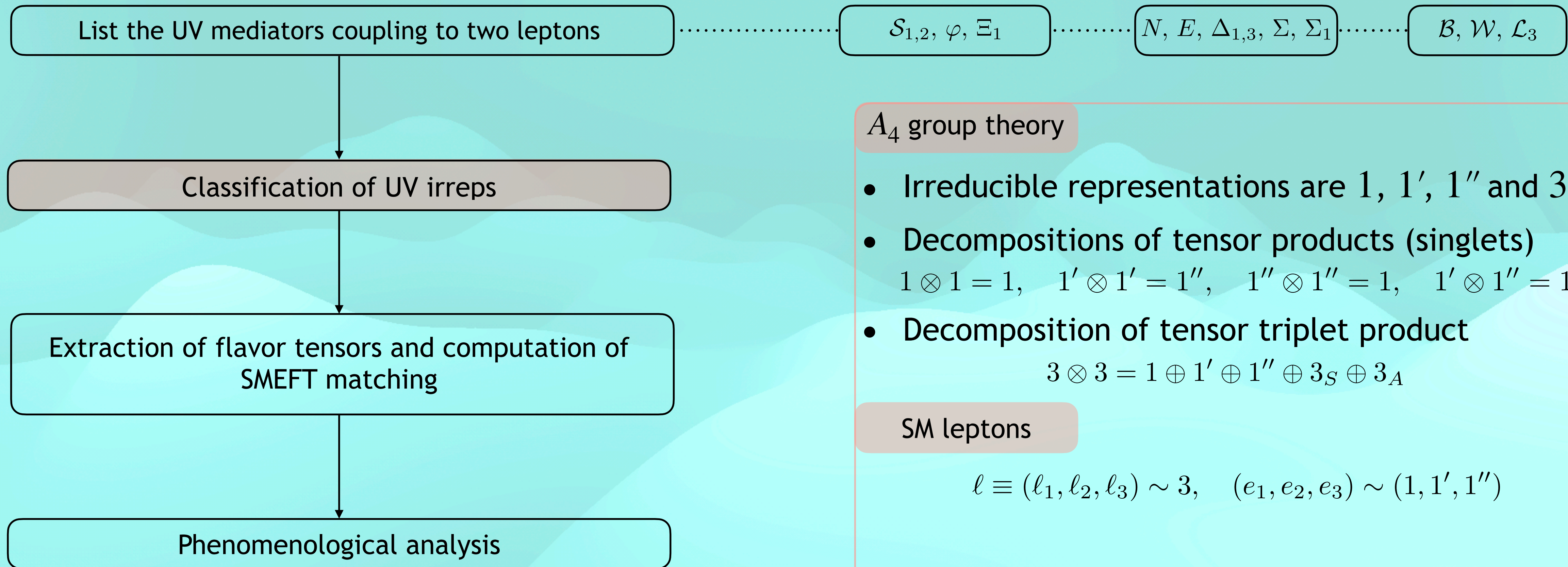
A_4 group theory

- Irreducible representations are $1, 1', 1''$ and 3
- Decompositions of tensor products (singlets)
 $1 \otimes 1 = 1, \quad 1' \otimes 1' = 1'', \quad 1'' \otimes 1'' = 1, \quad 1' \otimes 1'' = 1$
- Decomposition of tensor triplet product
 $3 \otimes 3 = 1 \oplus 1' \oplus 1'' \oplus 3_S \oplus 3_A$

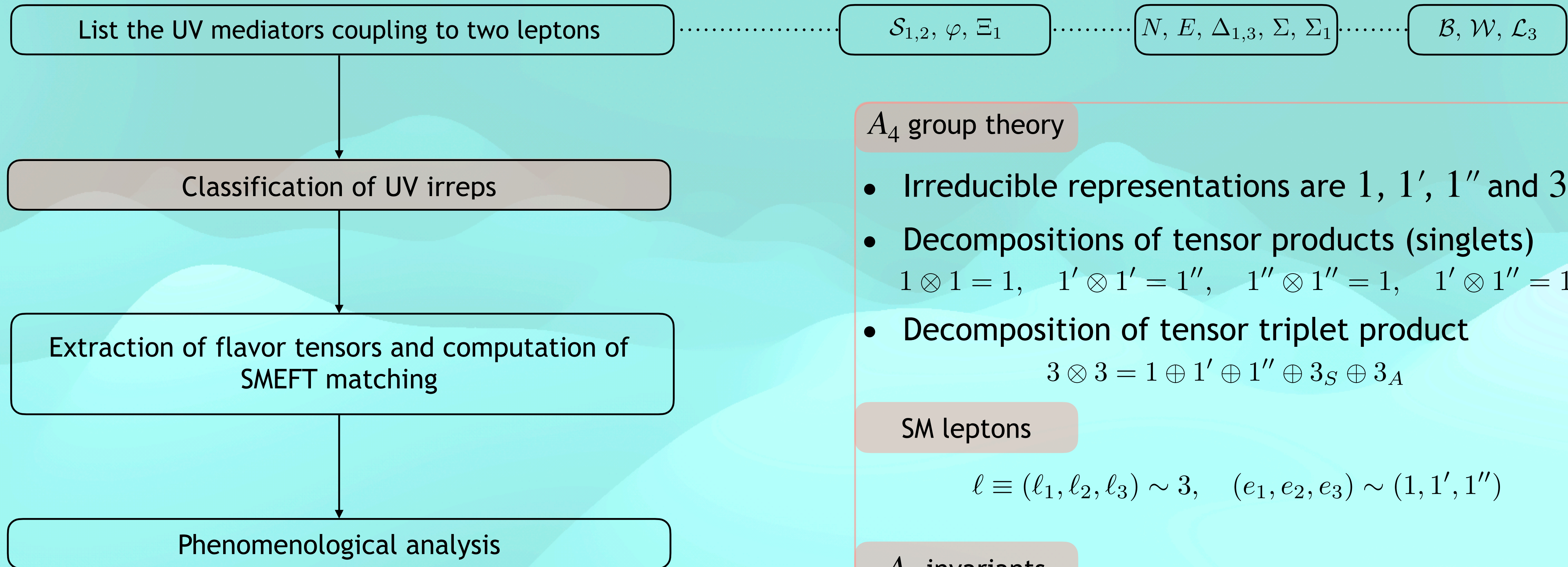
Procedure and example



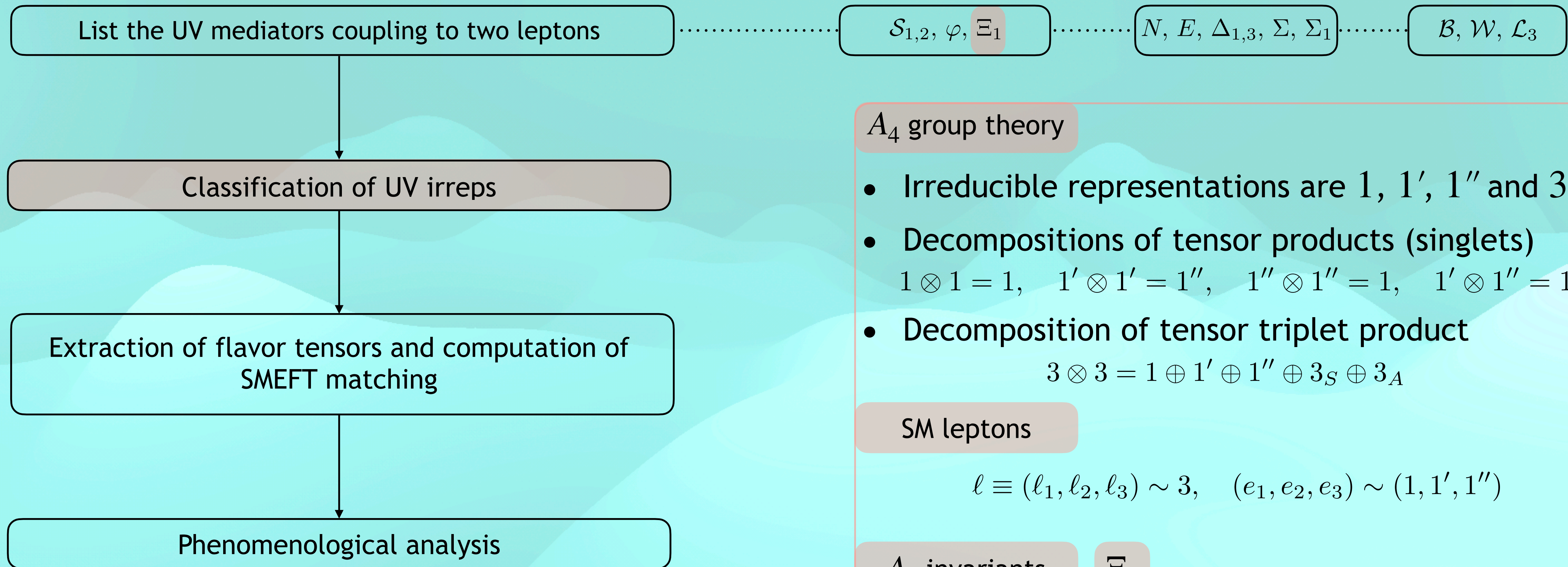
Procedure and example



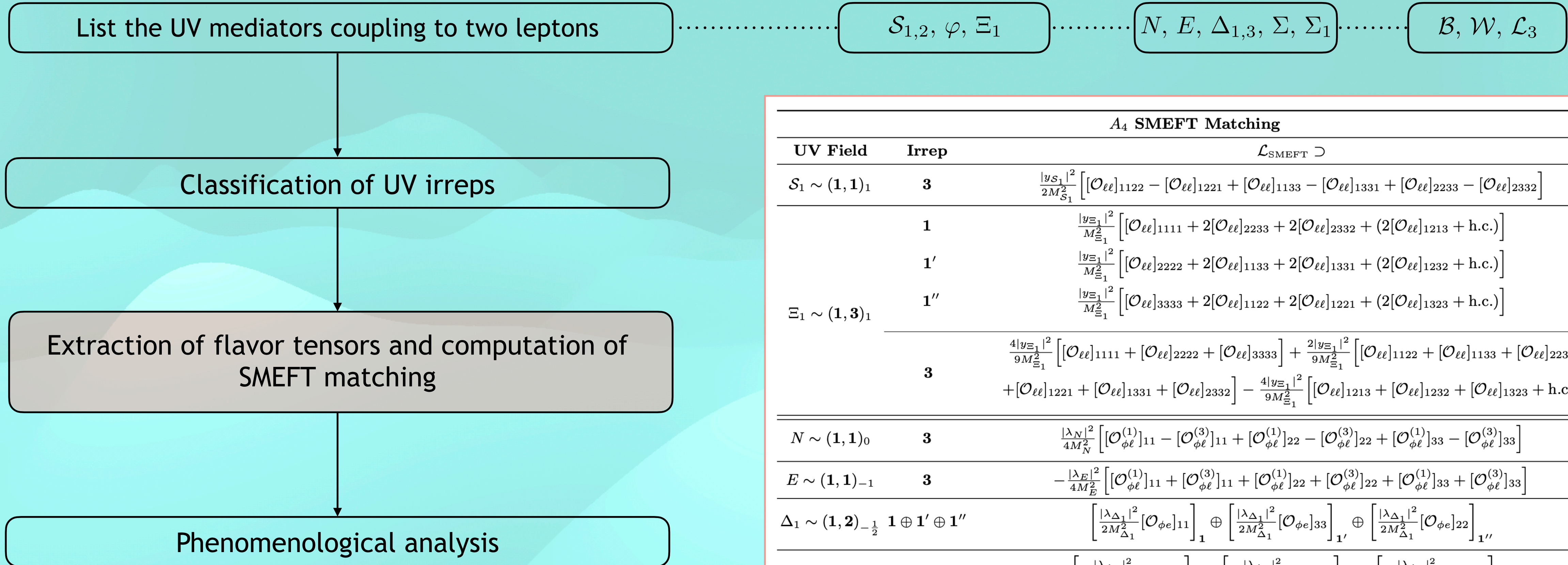
Procedure and example



Procedure and example

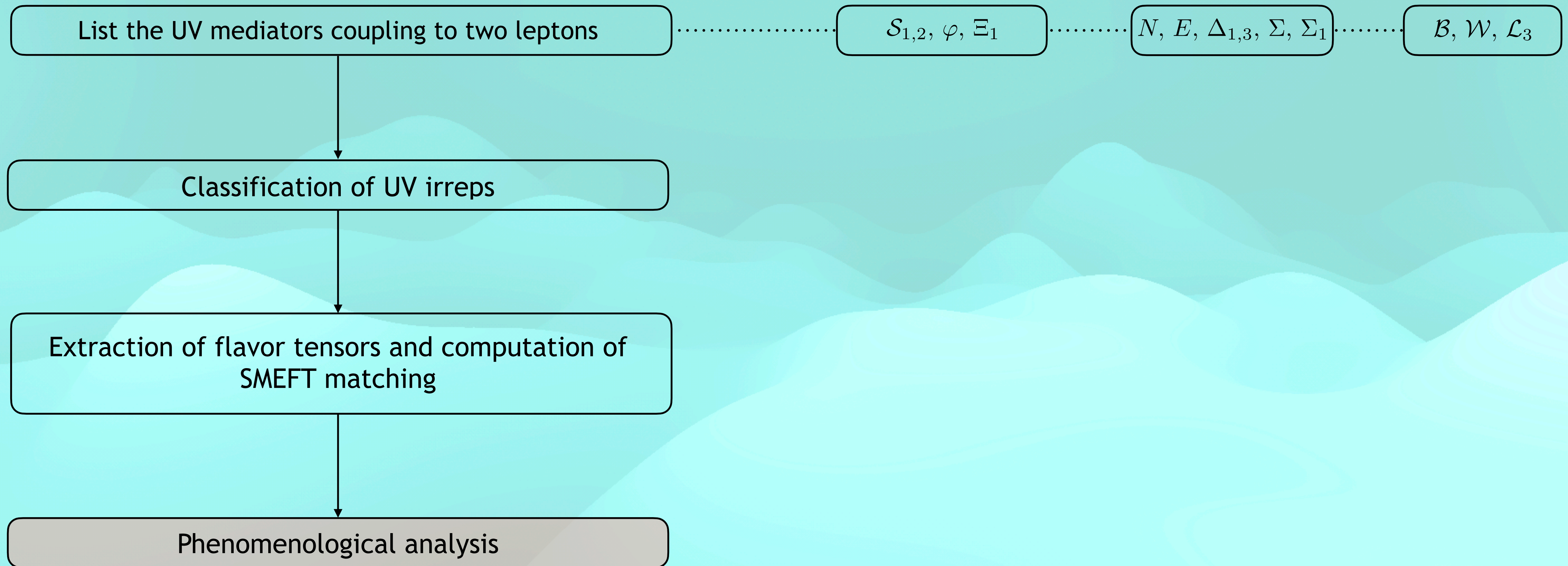


Procedure and results

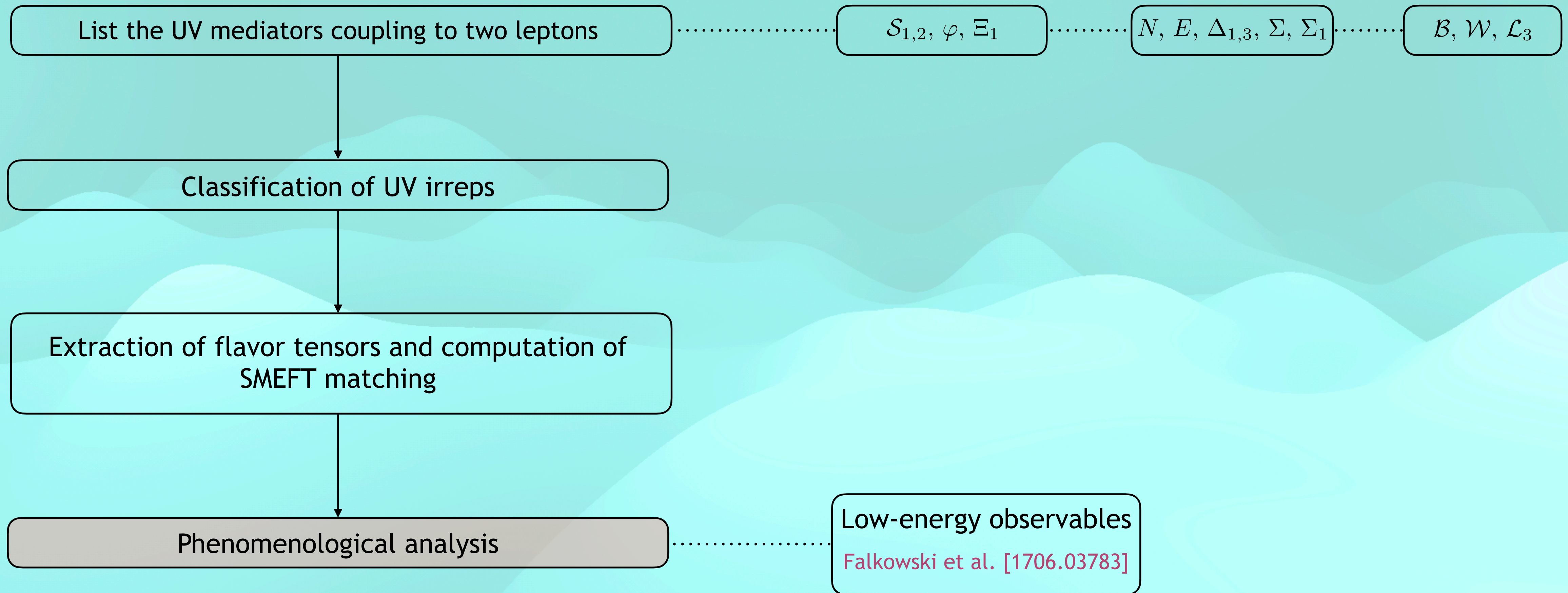


A_4 SMEFT Matching		
UV Field	Irrep	$\mathcal{L}_{\text{SMEFT}} \supset$
$\mathcal{S}_1 \sim (\mathbf{1}, \mathbf{1})_1$	$\mathbf{3}$	$\frac{ y_{\mathcal{S}_1} ^2}{2M_{\mathcal{S}_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{1122} - [\mathcal{O}_{\ell\ell}]_{1221} + [\mathcal{O}_{\ell\ell}]_{1133} - [\mathcal{O}_{\ell\ell}]_{1331} + [\mathcal{O}_{\ell\ell}]_{2233} - [\mathcal{O}_{\ell\ell}]_{2332} \right]$
$\Xi_1 \sim (\mathbf{1}, \mathbf{3})_1$	$\mathbf{1}$	$\frac{ y_{\Xi_1} ^2}{M_{\Xi_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{1111} + 2[\mathcal{O}_{\ell\ell}]_{2233} + 2[\mathcal{O}_{\ell\ell}]_{2332} + (2[\mathcal{O}_{\ell\ell}]_{1213} + \text{h.c.}) \right]$
	$\mathbf{1}'$	$\frac{ y_{\Xi_1} ^2}{M_{\Xi_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{2222} + 2[\mathcal{O}_{\ell\ell}]_{1133} + 2[\mathcal{O}_{\ell\ell}]_{1331} + (2[\mathcal{O}_{\ell\ell}]_{1232} + \text{h.c.}) \right]$
	$\mathbf{1}''$	$\frac{ y_{\Xi_1} ^2}{M_{\Xi_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{3333} + 2[\mathcal{O}_{\ell\ell}]_{1122} + 2[\mathcal{O}_{\ell\ell}]_{1221} + (2[\mathcal{O}_{\ell\ell}]_{1323} + \text{h.c.}) \right]$
	$\mathbf{3}$	$\frac{4 y_{\Xi_1} ^2}{9M_{\Xi_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{1111} + [\mathcal{O}_{\ell\ell}]_{2222} + [\mathcal{O}_{\ell\ell}]_{3333} \right] + \frac{2 y_{\Xi_1} ^2}{9M_{\Xi_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{1122} + [\mathcal{O}_{\ell\ell}]_{1133} + [\mathcal{O}_{\ell\ell}]_{2233} + [\mathcal{O}_{\ell\ell}]_{1221} + [\mathcal{O}_{\ell\ell}]_{1331} + [\mathcal{O}_{\ell\ell}]_{2332} \right] - \frac{4 y_{\Xi_1} ^2}{9M_{\Xi_1}^2} \left[[\mathcal{O}_{\ell\ell}]_{1213} + [\mathcal{O}_{\ell\ell}]_{1232} + [\mathcal{O}_{\ell\ell}]_{1323} + \text{h.c.} \right]$
$N \sim (\mathbf{1}, \mathbf{1})_0$	$\mathbf{3}$	$\frac{ \lambda_N ^2}{4M_N^2} \left[[\mathcal{O}_{\phi\ell}^{(1)}]_{11} - [\mathcal{O}_{\phi\ell}^{(3)}]_{11} + [\mathcal{O}_{\phi\ell}^{(1)}]_{22} - [\mathcal{O}_{\phi\ell}^{(3)}]_{22} + [\mathcal{O}_{\phi\ell}^{(1)}]_{33} - [\mathcal{O}_{\phi\ell}^{(3)}]_{33} \right]$
$E \sim (\mathbf{1}, \mathbf{1})_{-1}$	$\mathbf{3}$	$-\frac{ \lambda_E ^2}{4M_E^2} \left[[\mathcal{O}_{\phi\ell}^{(1)}]_{11} + [\mathcal{O}_{\phi\ell}^{(3)}]_{11} + [\mathcal{O}_{\phi\ell}^{(1)}]_{22} + [\mathcal{O}_{\phi\ell}^{(3)}]_{22} + [\mathcal{O}_{\phi\ell}^{(1)}]_{33} + [\mathcal{O}_{\phi\ell}^{(3)}]_{33} \right]$
$\Delta_1 \sim (\mathbf{1}, \mathbf{2})_{-\frac{1}{2}} \mathbf{1} \oplus \mathbf{1}' \oplus \mathbf{1}''$		$\left[\frac{ \lambda_{\Delta_1} ^2}{2M_{\Delta_1}^2} [\mathcal{O}_{\phi e}]_{11} \right]_{\mathbf{1}} \oplus \left[\frac{ \lambda_{\Delta_1} ^2}{2M_{\Delta_1}^2} [\mathcal{O}_{\phi e}]_{33} \right]_{\mathbf{1}'} \oplus \left[\frac{ \lambda_{\Delta_1} ^2}{2M_{\Delta_1}^2} [\mathcal{O}_{\phi e}]_{22} \right]_{\mathbf{1}''}$
$\Delta_3 \sim (\mathbf{1}, \mathbf{2})_{-\frac{3}{2}} \mathbf{1} \oplus \mathbf{1}' \oplus \mathbf{1}''$		$\left[-\frac{ \lambda_{\Delta_3} ^2}{2M_{\Delta_3}^2} [\mathcal{O}_{\phi e}]_{11} \right]_{\mathbf{1}} \oplus \left[-\frac{ \lambda_{\Delta_3} ^2}{2M_{\Delta_3}^2} [\mathcal{O}_{\phi e}]_{33} \right]_{\mathbf{1}'} \oplus \left[-\frac{ \lambda_{\Delta_3} ^2}{2M_{\Delta_3}^2} [\mathcal{O}_{\phi e}]_{22} \right]_{\mathbf{1}''}$
$\Sigma \sim (\mathbf{1}, \mathbf{3})_0$	$\mathbf{3}$	$\frac{ \lambda_{\Sigma} ^2}{16M_{\Sigma}^2} \left[[\mathcal{O}_{\phi\ell}^{(3)}]_{11} + 3[\mathcal{O}_{\phi\ell}^{(1)}]_{11} + [\mathcal{O}_{\phi\ell}^{(3)}]_{22} + 3[\mathcal{O}_{\phi\ell}^{(1)}]_{22} + [\mathcal{O}_{\phi\ell}^{(3)}]_{33} + 3[\mathcal{O}_{\phi\ell}^{(1)}]_{33} \right]$
$\Sigma_1 \sim (\mathbf{1}, \mathbf{3})_{-1}$	$\mathbf{3}$	$\frac{ \lambda_{\Sigma_1} ^2}{16M_{\Sigma_1}^2} \left[[\mathcal{O}_{\phi\ell}^{(3)}]_{11} - 3[\mathcal{O}_{\phi\ell}^{(1)}]_{11} + [\mathcal{O}_{\phi\ell}^{(3)}]_{22} - 3[\mathcal{O}_{\phi\ell}^{(1)}]_{22} + [\mathcal{O}_{\phi\ell}^{(3)}]_{33} - 3[\mathcal{O}_{\phi\ell}^{(1)}]_{33} \right]$

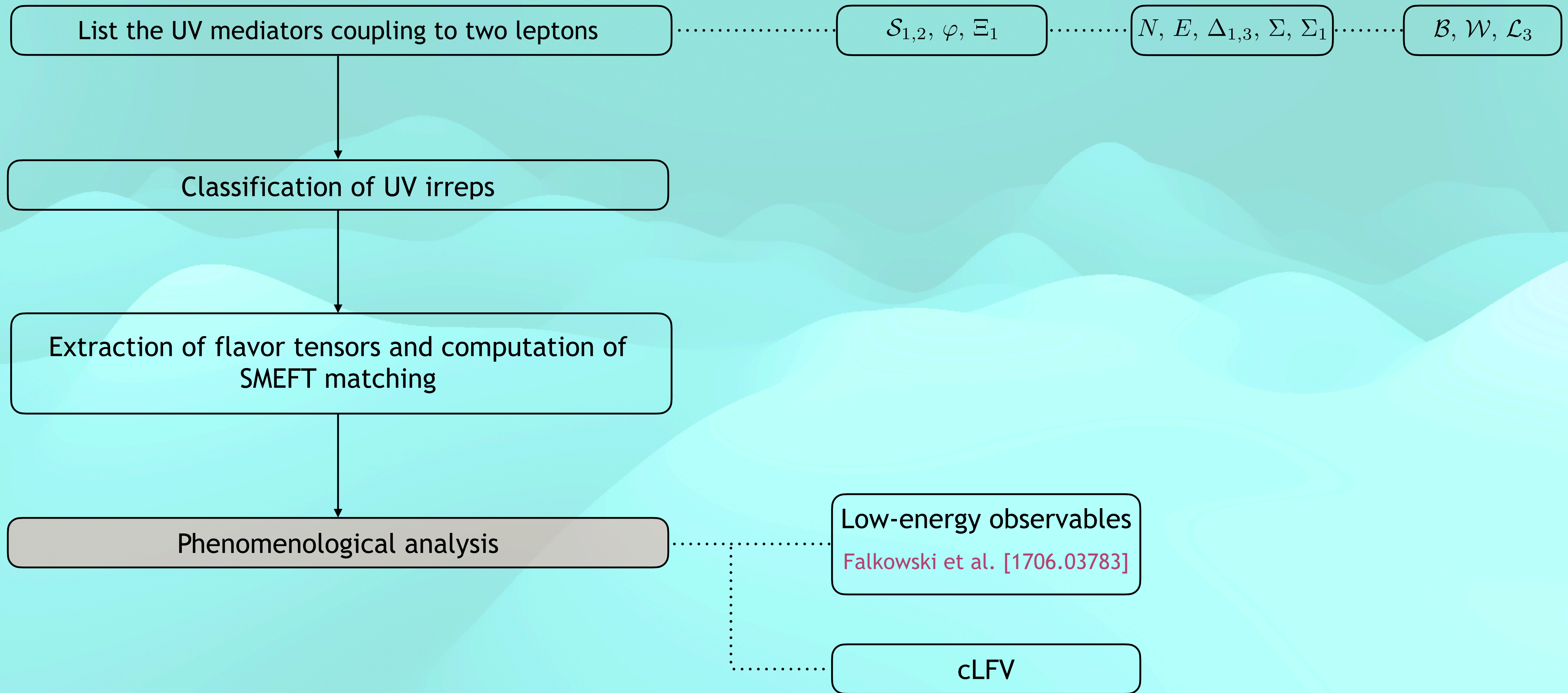
Procedure and results



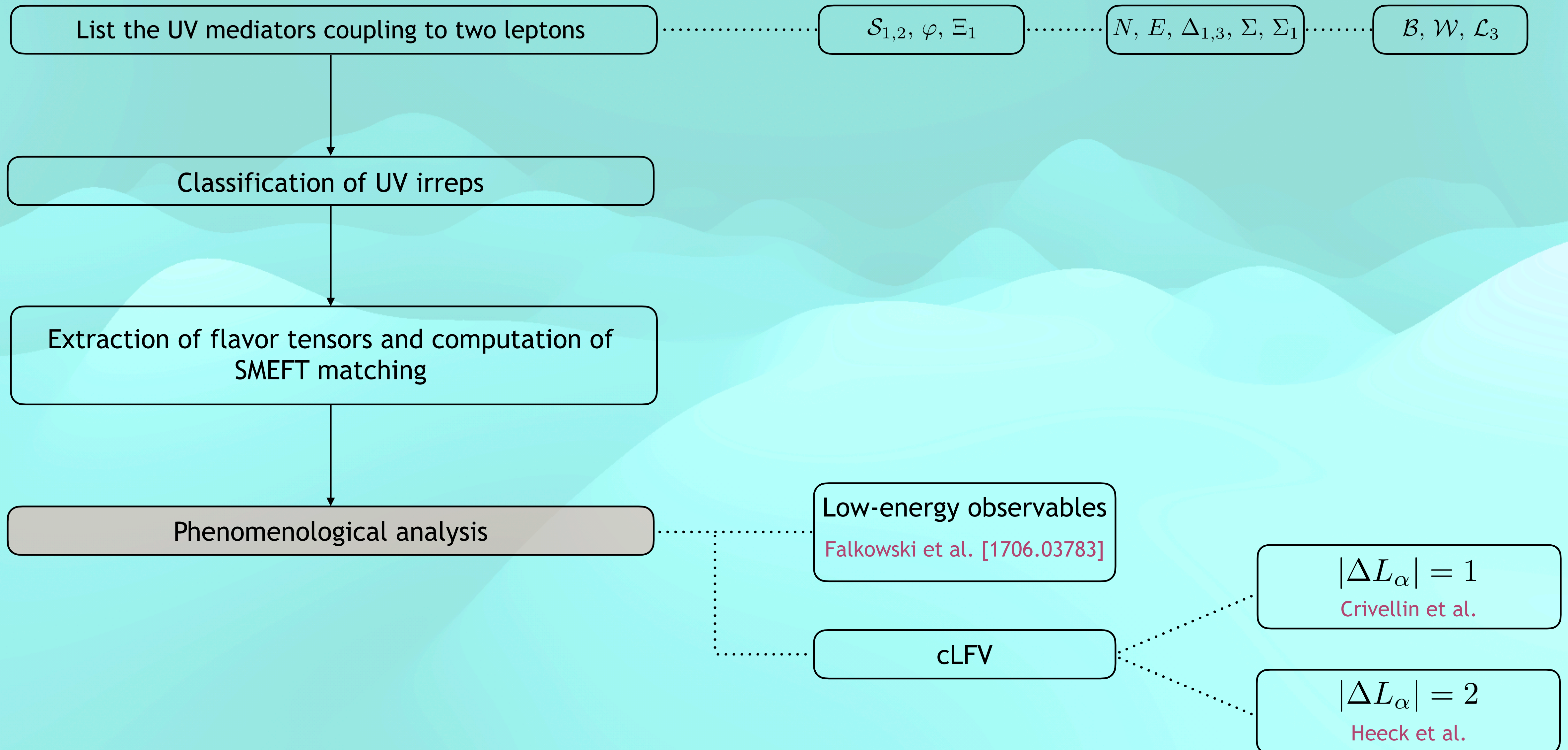
Procedure and results



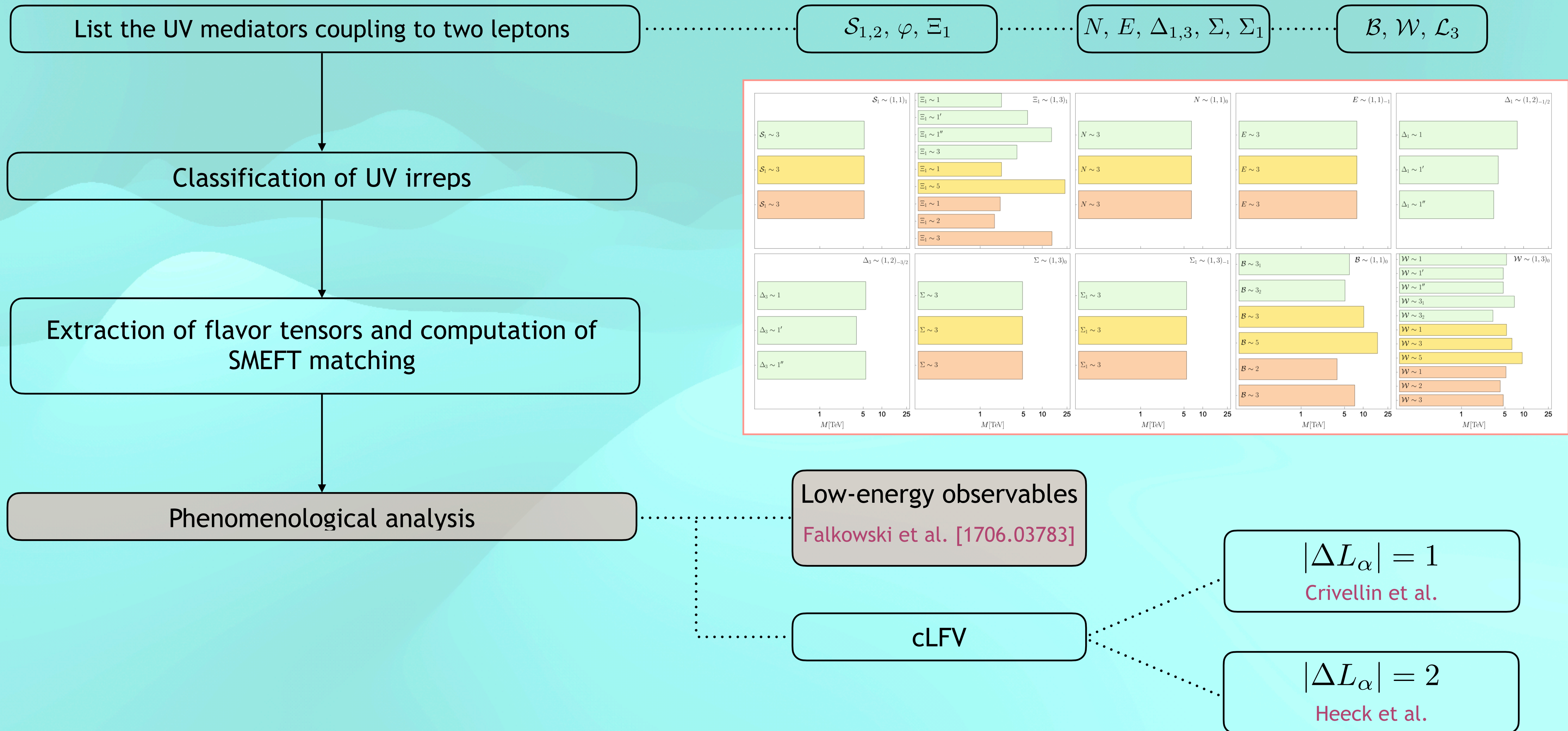
Procedure and results



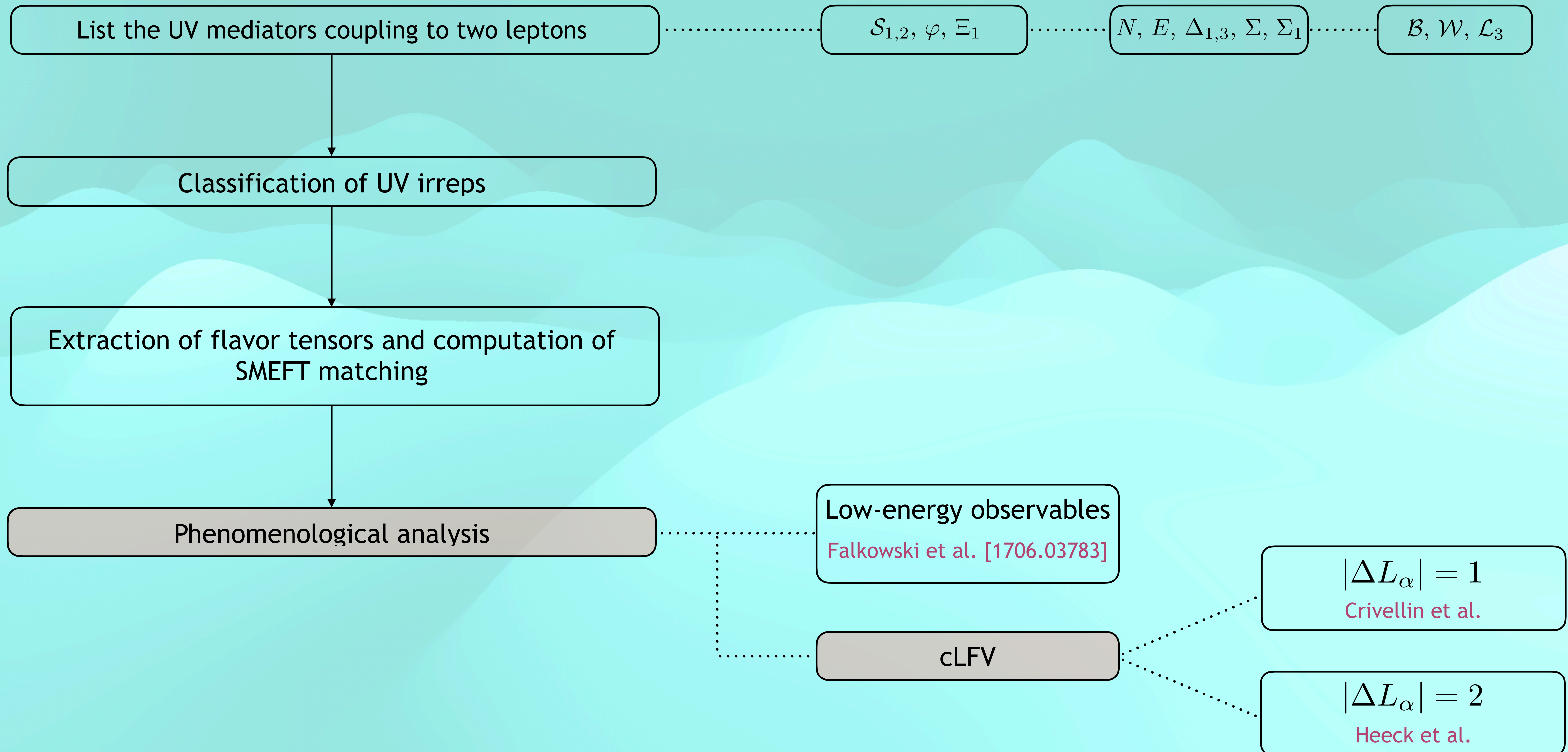
Procedure and results



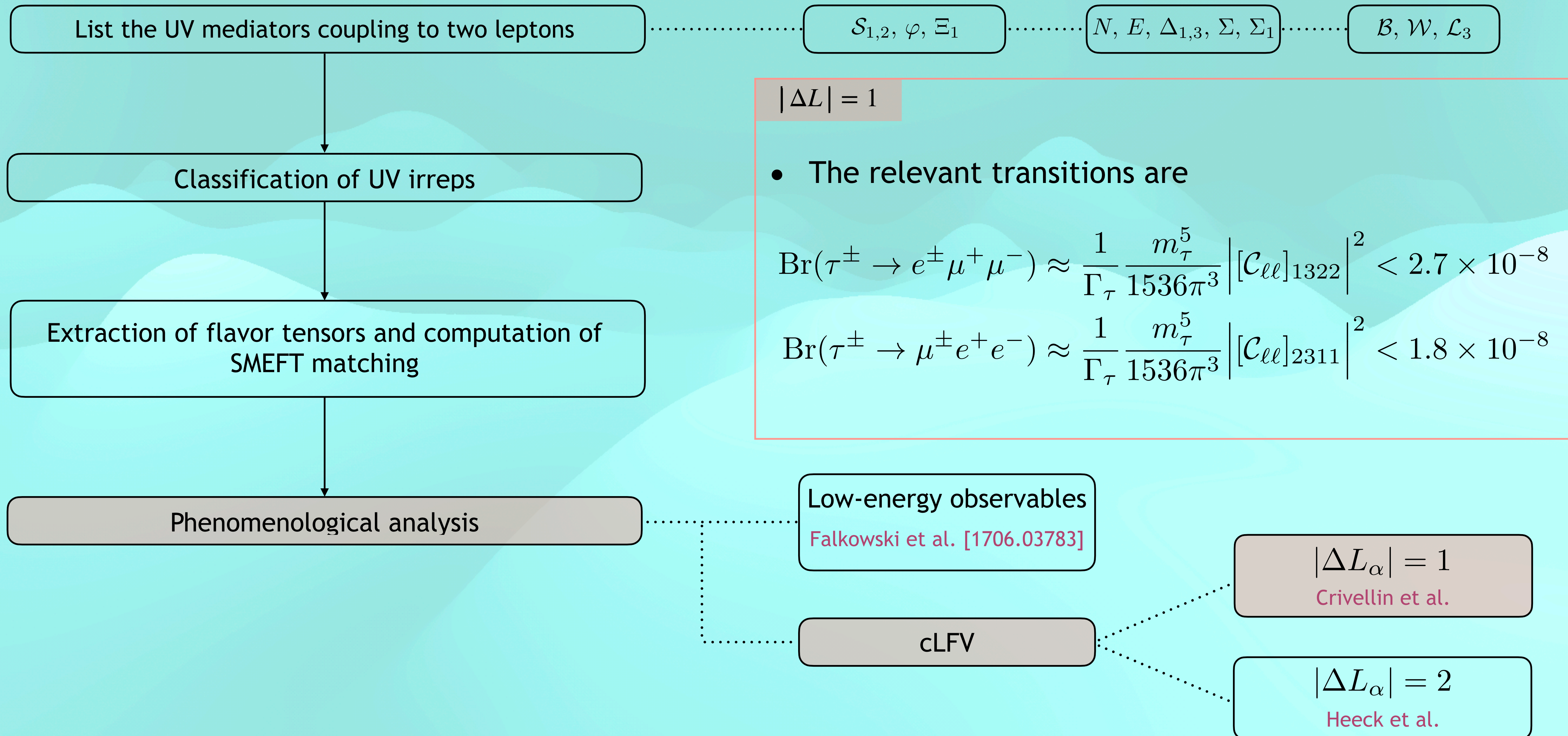
Procedure and results



Procedure and results



Procedure and results



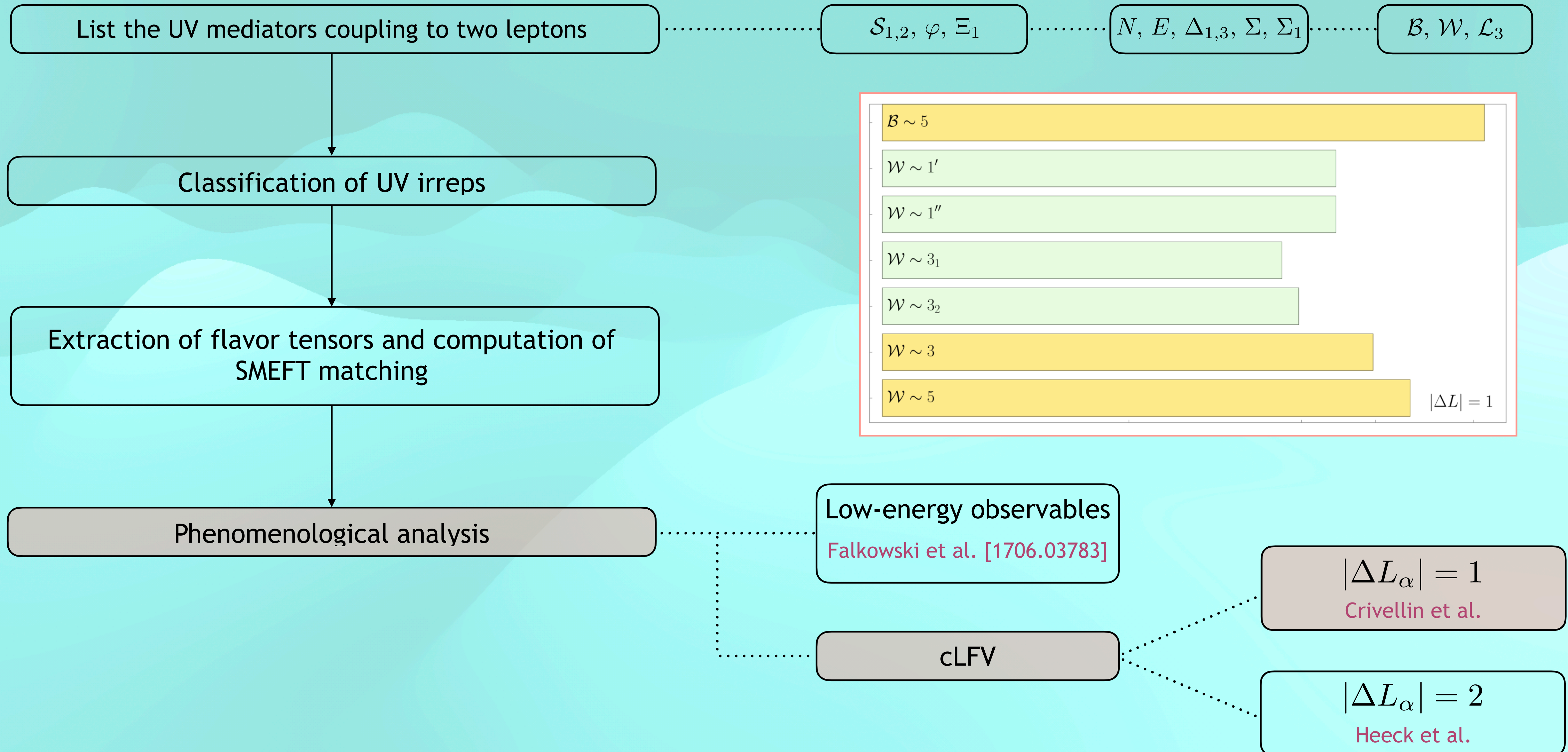
$|\Delta L| = 1$

- The relevant transitions are

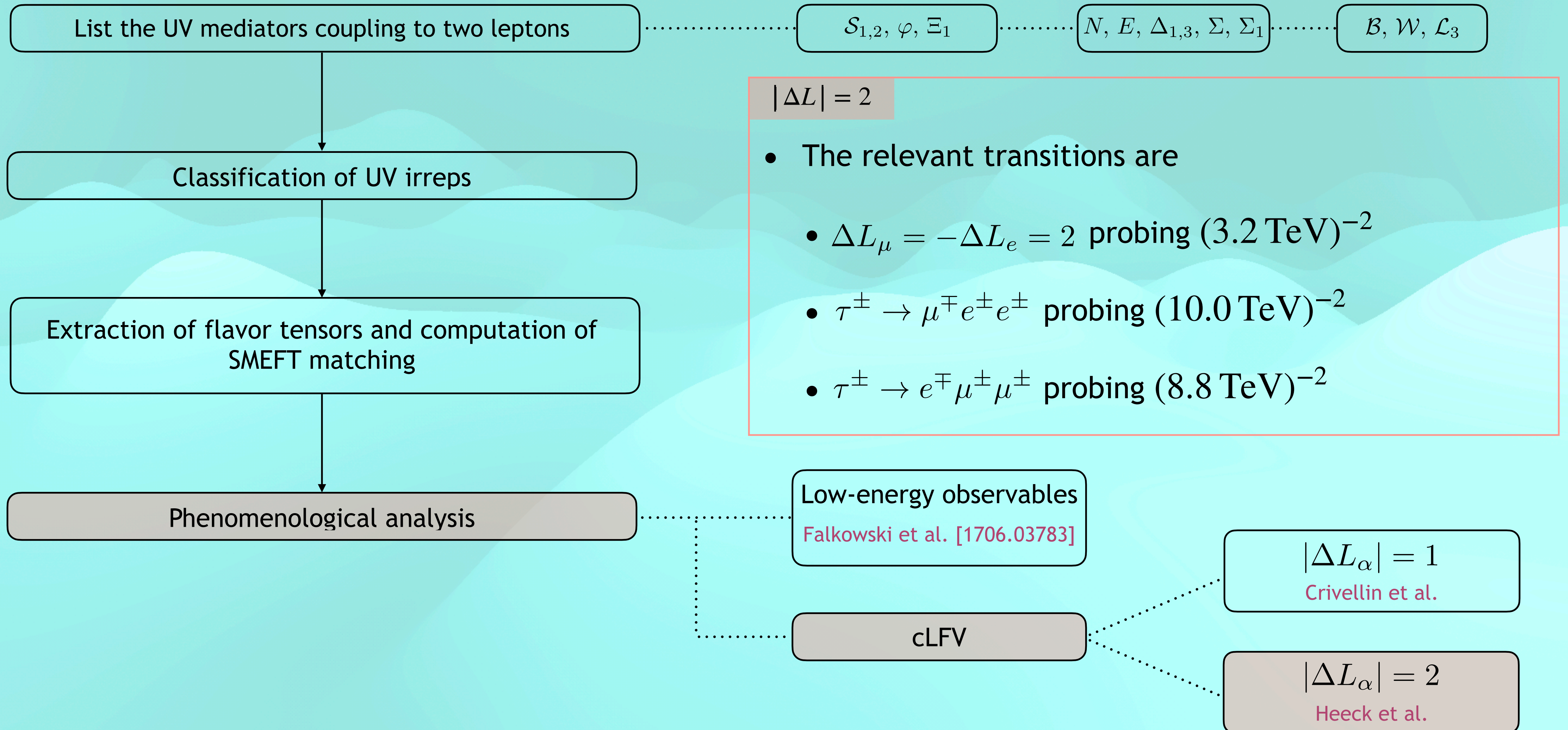
$$\text{Br}(\tau^\pm \rightarrow e^\pm \mu^+ \mu^-) \approx \frac{1}{\Gamma_\tau} \frac{m_\tau^5}{1536\pi^3} \left| [\mathcal{C}_{\ell\ell}]_{1322} \right|^2 < 2.7 \times 10^{-8}$$

$$\text{Br}(\tau^\pm \rightarrow \mu^\pm e^+ e^-) \approx \frac{1}{\Gamma_\tau} \frac{m_\tau^5}{1536\pi^3} \left| [\mathcal{C}_{\ell\ell}]_{2311} \right|^2 < 1.8 \times 10^{-8}$$

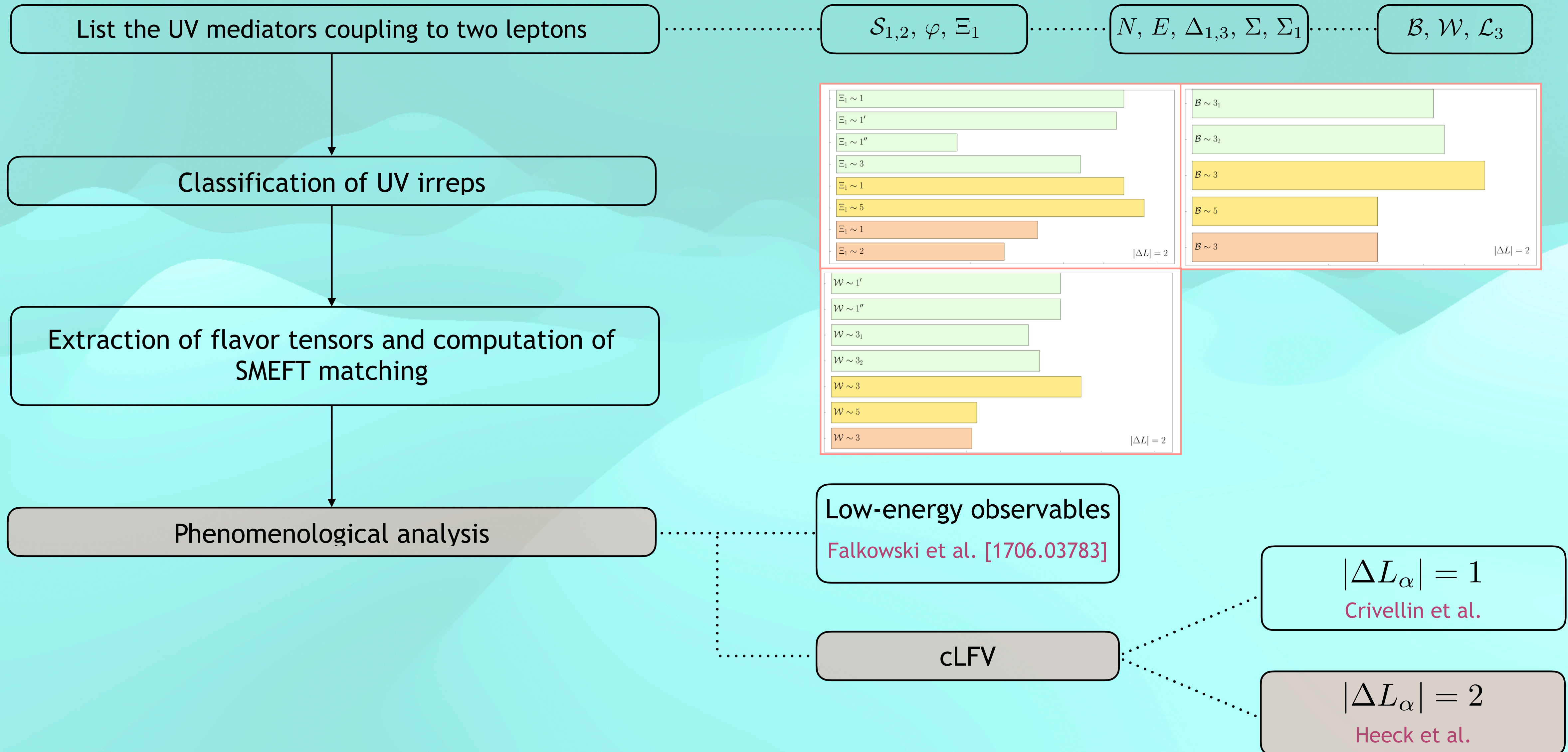
Procedure and results



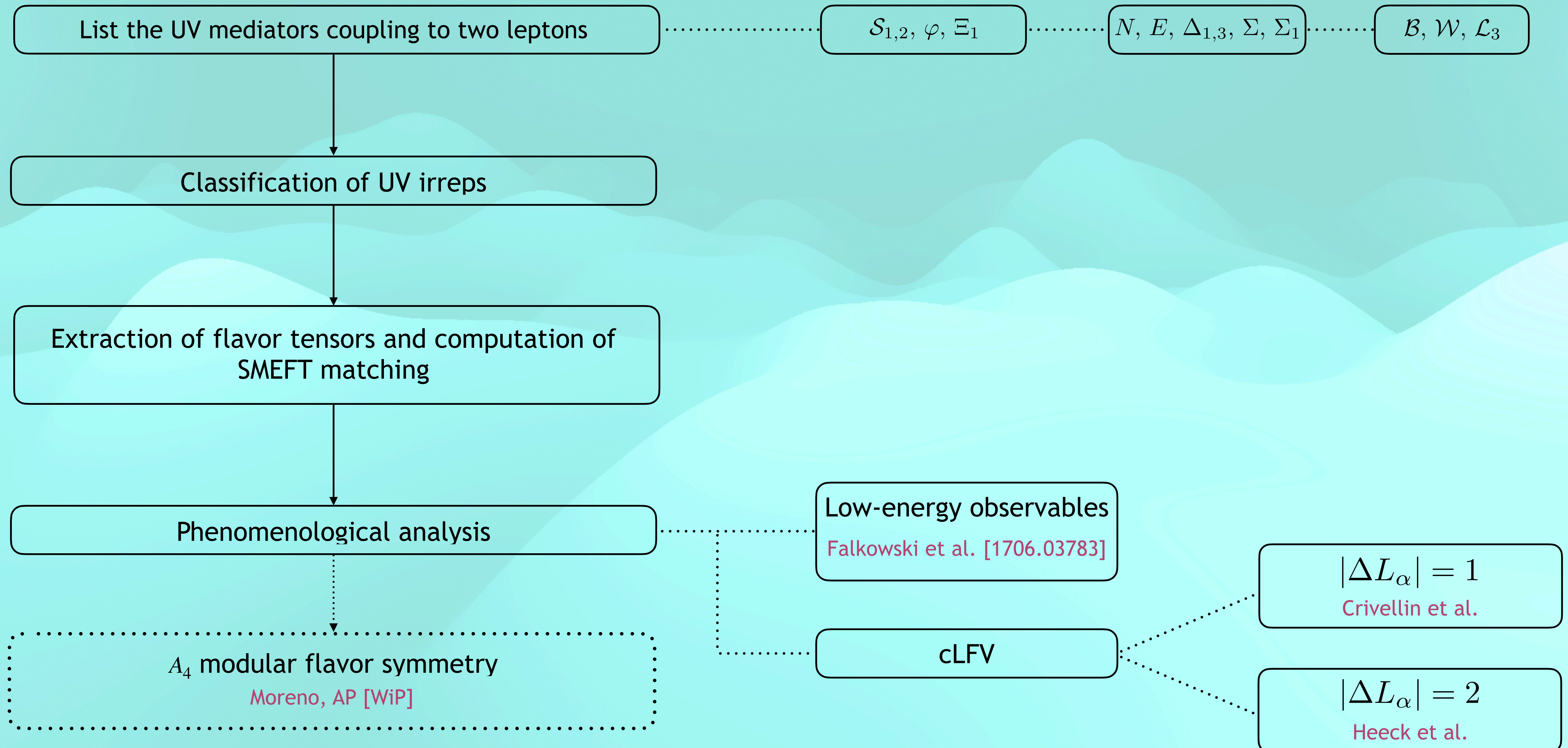
Procedure and results



Procedure and results



Procedure and results



Conclusions

- SMEFT is a powerful and robust EFT framework
- Connection between flavor symmetries and the SMEFT
- Landscape of dimension-6 operators
- Connection between the parameter landscape and UV
- Classification and phenomenological analysis of the UV mediators
- Inclusion of (modular) discrete flavor symmetries in the lepton sector

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