1. Electric Dipole Moments

The Standard Model (SM) cannot account for the observed matter - antimatter imbalance in the Universe. New sources of CP violation generate particle EDMs.

- With current sensitivity on EDMs, the SM represents a negligible background.
- Relevant operators for hadronic EDMs:

<table>
<thead>
<tr>
<th>QUARK EDM</th>
<th>QUARK CEDM</th>
<th>WEINBERG OP.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma^\dagger \gamma d_{q} \bar{q} \gamma^\dagger \gamma q F_{\gamma}$</td>
<td>$\gamma^\dagger \gamma d_{q} \bar{q} \gamma^\dagger \gamma q C_{\gamma}$</td>
<td>$\gamma^\dagger \gamma d_{q} \bar{q} \gamma^\dagger \gamma q \tilde{F}_{\gamma}$</td>
</tr>
</tbody>
</table>

2. EDM: Experimental Status

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Atomic</th>
<th>Nuclear</th>
<th>Hadron</th>
<th>QCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDM</td>
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<tr>
<td>CEDM</td>
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<td>Weinberg op.</td>
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<td>EDM systems: direct EDM searches</td>
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</tbody>
</table>

- Stringest limits on electron and neutron EDM
- New experimental program on the search for charm- and bottom-baryon EDM
  - direct access to (chromo-)EDM of heavy quarks [1612.06769, 2010.11902, ...]

3. Heavy Quarks: Indirect Limits

Attempts to put limits to the dipole couplings of charm and bottom quarks have used many different observables [1312.2589, 0902.3059, 0811.2380, hep-ph/9403304, 0712.0154]

- $d$-quark EDM ($\rightarrow$ neutron)
- $b$-quark EDM ($\rightarrow$ neutron)

4. Heavy Quarks: Improved Indirect Limits

H. Gisbert, JRV, [1905.02513]

- Difference between EDM and CEDM bounds
- $|d_\text{upw}| < 4.4 \times 10^{-17}$ cm
- $|d_\text{upw}| < 1.0 \times 10^{-22}$ cm

- Related through QED corrections in RGEs.
- Overlooked due to "larger" QCD corrections
- Improvement of a factor $10^4$ in charm EDM and $10^5$ in bottom EDM
- $|d_\text{new}| < 1.5 \times 10^{-21}$ cm
- $|d_\text{new}| < 1.2 \times 10^{-26}$ cm

5. Implications for New Physics

**SUSY**

- MSSM: Up-dating predictions of [hep-ph/0204238] with LHC bounds on the masses, still $d_\gamma \sim 10^{-39}$ cm
- Needs detailed analysis.
- BLMSM: Specially large predictions [1610.07314] from the new phases in this model, $d_\gamma \sim 10^{-39}$ cm.
- New analysis with our bounds [1910.05868].
- R-parity violating SUSY: Leading contribution at two loops [1406.3731]. Bounds useful to remove extended regions of fine-tuned cancellations.

**LEPTOQUARKS**

- Scalar leptoquark $R_C$ (2,2/6) Recently motivated by the anomalies in $b \to c\tau\nu$ transitions.
- Needs imaginary coupling $\text{Im}(\gamma_5)$ to simultaneously explain $R_N$ and $R_S$ generates a charm EDM [1009.9114]
- Future sensitivity on neutron ($d_\gamma < 10^{-27}$ cm) can rule out the model through our connection neutron $\Rightarrow$ charm EDM

**MFV / Coloured Higgs**

- Most restrictive flavor observable $B(\bar{B} \to X_s\mu^+\mu^-)$ [1504.00839]
- New bottom EDM bound competes in the same plane of parameter space
- Are the light-quark EDMs even more restrictive?
- Needs complete analysis of EDM bounds

6. Full EDM Analysis in Color-Octet Scalar Model

H. Gisbert, V. Miralles, JRV, [2111.09397]

- Dipole (1-loop) [1905.02513]
- Suppressed by light-quark masses in Yukawa couplings
- Neutral scalars cancel out, $d_\gamma(S^0) = -d_\gamma(S^0)$
- Charged-scalar ($S^\pm$) contributions dominate bottom quark EDM

- Dipole (2-loops)

- Weinberg operator (2-loops)

- Charged scalar dominates via effective $\tilde{\delta}_S$
- Described method to recover analytic expressions

**Conclusions**

- Current neutron and mercury EDM limits provide best restrictions on the Yukawa phases of this model
- Complementary to flavor obs. (e.g. $B(\bar{B} \to X_s\gamma)$)
- Allowed regions for up ($\delta_0$) and down ($\delta_0$) Yukawa couplings
- Powerful restrictions from neutron EDM for non-zero phases $\text{arg}^{\gamma}_{\text{upw}}(\tilde{\delta}_S) \neq 0$