Chapter 6

Conversion of Anomalies

Scholium:

1. Other regular scheme: Dimensional regularization: subtlety in continuing ϵ symbol. Lattice regularization: doubling of fermions. The anomaly can be derived from axions (CVC, bose statistics, ...) so they all must give the same answer.

2. Higher orders do not renormalize the anomaly. Looking in one particles gives. consequence factor, allows shifts (Adler-Bardeen).

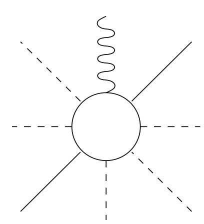

Figure 6.1: Higher Orders.

This correlates with

$$e^2 F\tilde{F} + f^2 \to F\tilde{F} + \frac{1}{e^2}F^2 \tag{6.1}$$

numerical coefficient.

3. Closely related in non-decoupling of heavy quarks in $h \to gg$ vertex.

$$\int d^a p \frac{trkkM}{(p^2+M^2)^3} \sim \frac{1}{M} \tag{6.2}$$

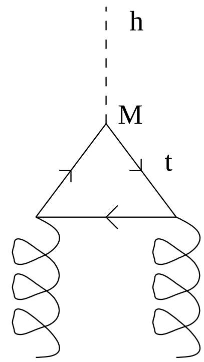

Figure 6.2: Non-Decoupling.

finite as $M \to \infty$

Key to phenomenology.

4. This is also closely commuted to trace anomaly, scaling anomaly. Note these do get renormalized.

5. In path $\int$, the anomaly arises from non-invariance of the measure (Fujikawa) .

6.
$$\partial_\mu j^{\mu 5} = K\epsilon^{\alpha\beta\sigma\delta}\partial_\alpha A_\beta \partial_\gamma A_\delta = K\partial_\alpha(\epsilon^{\alpha\beta\sigma\delta} A_\beta \partial_\gamma A_\delta) \tag{6.3}$$

so there is a conserved current

$$\tilde{j}^{\mu S} = j^{\mu S} - K\epsilon^{\alpha\beta\sigma\delta} A_\beta \partial_\gamma A_\delta \tag{6.4}$$
$$\partial_\mu \tilde{j}^{\mu S} = 0 \tag{6.5}$$

This is not gauge-invariant, however, only j^μ clearly current to physical states.

7. Anomaly cancellation in the standard model

$$SU(3)_V \times SU(2)_L \times U(1)_{complicated} \tag{6.6}$$
$$SU(2)^3 \quad (vanishing\ tr(\tau\{\tau\ \tau\})) \tag{6.7}$$
$$SU(2)^2 \times U(1) \tag{6.8}$$
$$\underbrace{\frac{1}{6}}_{quarks} \cdot \underbrace{3}_{leptors} - \frac{1}{2} = 0 \tag{6.9}$$

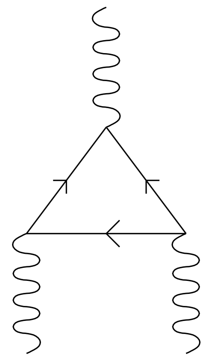

Figure 6.3: L–Handed.

note connection.

$U(1)^3$:

$$L \;:\; (\frac{1}{6})^3 \cdot 6 + (-\frac{1}{2})^3 \cdot 2 = -\frac{2}{9} \tag{6.10}$$

$$R \;:\; (\frac{2}{3})^3 \cdot 3 + (-\frac{1}{3})^3 \cdot 3 + (-1)^3 = -\frac{2}{9} \tag{6.11}$$

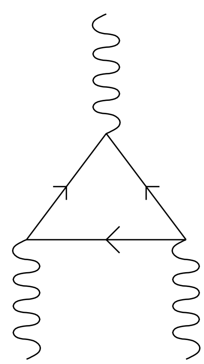

Figure 6.4: $U(1)^3$.

8. Non-cancellation of B, L anomalous. All L–handed $(\frac{1}{2})^2 + (-\frac{1}{2})^2$. $B - L$ is not anomalies.

9. Anomalies relevant to QCD.

$$m_u, m_d \approx 0 \tag{6.12}$$

QCD + QED

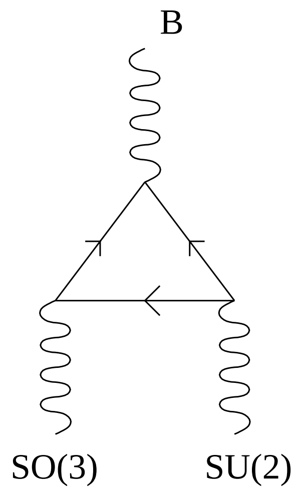

Figure 6.5: Non-Cancellation.

A meta-spealation I find fascinating: Symmetry restoration by anomalies. This would in some cases give symmetry $\Rightarrow$ QM.

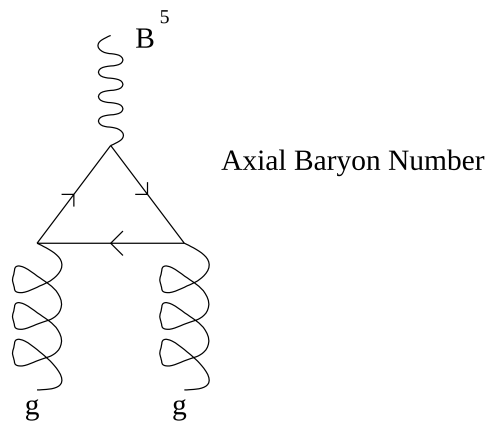

Figure 6.6: QCD.

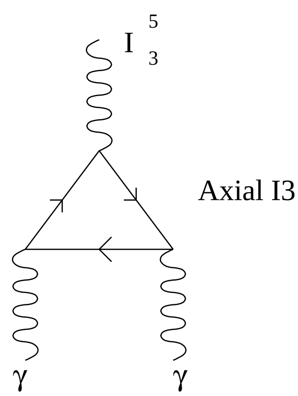

Figure 6.7: QCD + QED.