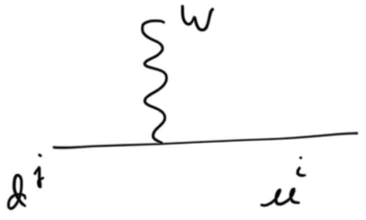
CKM MATRIX DETERMINATION & CP VIOLATION

CKM MATRIX



$$\mathcal{L}_W = \frac{g}{\sqrt{2}}\left[\bar{u}_{Li} V_{ij} \gamma^\mu d_{Lj} W_\mu^+ + \bar{d}_{Lj} V_{ij}^* \gamma^\mu u_{Li} W_\mu^-\right]$$

V unitary 4 parameters $\begin{cases} 3 \text{ moduli} \\ 1 \text{ phase} \leftarrow \text{CP VIOLATION} \end{cases}$

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

SM extremely predictive

$$V = \begin{bmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13}e^{-i\delta} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13}e^{i\delta} & c_{12}c_{23} - s_{12}s_{23}s_{13}e^{i\delta} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13}e^{i\delta} & -c_{12}s_{23} - s_{12}c_{23}s_{13}e^{i\delta} & c_{23}c_{13} \end{bmatrix}$$

$\underbrace{\theta_{12}, \theta_{13}, \theta_{23}}_{\text{moduli}}$ $\underbrace{\delta}_{\text{phase}}$ $\cos\theta_{ij} = c_{ij}$, $\sin\theta_{ij} = s_{ij}$

→ V is extremely hierarchical $\mathbb{1}$ + small corrections

$s_{12} \approx 0.22$

s_{13}, s_{23} are very small

$\delta \sim 66°$

→ Use this hierarchy to find a better parametrisation

[…] … as an expansion

[O(1) parameters] → use λ as an expansion parameter

$$\lambda^2 = \frac{|V_{us}|^2}{|V_{ud}|^2 + |V_{us}|^2} \qquad s_{12} = \lambda$$

$$A^2\lambda^4 = \frac{|V_{cb}|^2}{|V_{ud}|^2 + |V_{us}|^2} \qquad s_{13} = A\lambda^2$$

$$\bar\rho + i\bar\eta = -\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}$$

Use unitarity of the CKM matrix to define / express all the matrix elements in terms of these 4 param.

(expand in powers of λ)

$$V = \begin{bmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\bar\rho - i\bar\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\bar\rho - i\bar\eta) & -A\lambda^2 & 1 \end{bmatrix} + O(\lambda^4)$$

$\bar\eta$ related to CP violation [V_{td}, V_{ub} first matrix elements to feature $\bar\eta$ in the expansion]

λ related to Cabibbo angle

→ define a quantity assessing CP violation