

Standard parametrization of V_{CKM} :

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

$$\begin{pmatrix} d_L' \\ s_L' \\ b_L' \end{pmatrix} = \begin{pmatrix} V_{CKM} \end{pmatrix} \begin{pmatrix} d_L \\ s_L \\ b_L \end{pmatrix}$$

Gauge e-states mass e-states

$$= \underbrace{\begin{pmatrix} 1 & & \\ & \cos \theta_{23} & \sin \theta_{23} \\ & -\sin \theta_{23} & \cos \theta_{23} \end{pmatrix}}_{\text{active rotation about 1st gen. axis.}} \underbrace{\begin{pmatrix} \cos \theta_{13} & 0 & \sin \theta_{13} e^{i\delta} \\ 0 & 1 & 0 \\ -\sin \theta_{13} e^{i\delta} & 0 & \cos \theta_{13} \end{pmatrix}}_{\text{PASSIVE rotation about 2nd gen. axis.}} \underbrace{\begin{pmatrix} \cos \theta_{12} & \sin \theta_{12} & 0 \\ -\sin \theta_{12} & \cos \theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{active rotation about 3rd gen. axis [Cabbibo rotation]}}$$

$$= \begin{pmatrix} C_{12} S_{13} & S_{12} C_{23} & S_{13} e^{i\delta} \\ -S_{12} C_{23} - C_{12} S_{23} S_{13} e^{i\delta} & C_{12} C_{23} - S_{12} S_{23} S_{13} e^{i\delta} & S_{23} C_{13} \\ S_{12} C_{23} - C_{12} C_{23} S_{13} e^{i\delta} & -C_{12} S_{23} - S_{12} C_{23} S_{13} e^{i\delta} & S_{23} C_{13} \end{pmatrix}$$

Values: CKM Fitter 2013

$$S_{12} = \lambda = \frac{|V_{us}|}{\sqrt{|V_{ud}|^2 + |V_{us}|^2}} = \frac{0.22457}{\sqrt{(0.974455)^2 + (0.22457)^2}} = 0.224571$$

$$S_{23} = A \lambda^2 = \lambda \left| \frac{V_{cb}}{V_{us}} \right| = \lambda \left(\frac{0.04151}{0.22457} \right) = 0.041510$$

$$S_{13} e^{i\delta} = V_{ub}^* = A \lambda^3 (\rho + i\eta) = \frac{A \lambda^3 (\bar{\rho} + i\bar{\eta}) \sqrt{1 - A^2 \lambda^4}}{\sqrt{1 - \lambda^2} [1 - A^2 \lambda^4 (\bar{\rho} + i\bar{\eta})]} = 0.00355 e^{i(1.217)}$$

$$\theta_{12} = \arcsin(0.224571) = 0.226502 = 12.978^\circ$$

$$\theta_{23} = \arcsin(0.041510) = 0.041522 = 2.379^\circ$$

$$\theta_{13} = \arcsin(0.00355) = 0.00355 = 0.2034^\circ$$

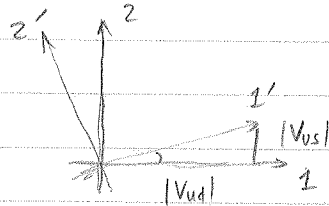
$$\delta = 1.217 = 69.7096^\circ$$

Wolfenstein parametrization.

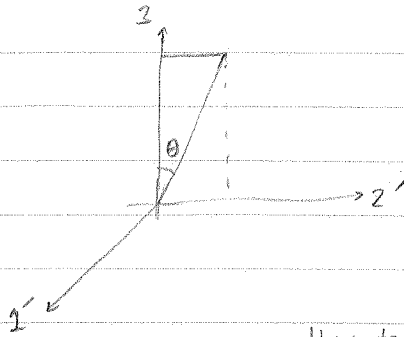
→ motivated by hierarchy $S_{13} \ll S_{23} \ll S_{12} \ll 1$

$\xrightarrow{\times 11.7}$ $\xrightarrow{\times 5.41}$ $\xrightarrow{\times 4.45}$
 $S_{13} \ll S_{23} \ll S_{12} \ll 1$

$$S_{12} \equiv \lambda = \frac{|V_{us}|}{\sqrt{|V_{ud}|^2 + |V_{us}|^2}}$$



$$S_{23} \equiv$$



How to understand other definitions?

Measuring the elements of V_{CKM} :

