B PHYSICS AND CP VIOLATION

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- U-spin: Equal CP rate asymmetries in pairs of charmless decays $(M.G.)$

- Determination of weak phases

  - $\phi_3 \equiv \gamma$ from U-spin
    $B^0 \to K^\pm\pi^\mp,\ B_s \to K^\mp\pi^\pm$ $(M.G.\ \&\ J.\ Rosner)$

  - Flavor SU(3): What's special about
    $$\frac{2\Gamma(B^\pm \to K^\pm\pi^0)}{\Gamma(B^\pm \to K^0\pi^\pm)} = 1.45 \pm 0.46 \neq 1\ ?$$
    $(M.\ Neubert\ \&\ J.\ Rosner)$

  - $\phi_2 \equiv \alpha$ from $B \to \pi\pi$
    isospin analysis and alternatives $(D.\ London)$

  - Other determinations of $\phi_3 \equiv \gamma$
    $B^\pm \to DK^\pm$ $(D.\ Atwood,\ S.\ Oh)$
    $B_s(t) \to D_sK$ $(A.\ Falk)$

Theorem about equal CP rate differences

$$\mathcal{H}_{\text{eff}}^{\Delta S=1} = \frac{G_F}{\sqrt{2}} V_{ub}^* V_{us} \left(\sum_1^2 c_i Q_i^{us} + \sum_3^{10} c_i Q_i^s \right)$$

$$+ \quad V_{cb}^* V_{cs} \left(\sum_1^2 c_i Q_i^{cs} + \sum_3^{10} c_i Q_i^s \right)$$

U-Spin Doublets $\begin{pmatrix} d \\ s \end{pmatrix}$ $\quad \bar{b}u\bar{u}s$, $\bar{b}c\bar{c}s$ $\quad \bar{b}s\Sigma_{q'}(e_{q'})\bar{q}'q'$

$$\mathcal{H}_{\text{eff}}^{\Delta S=1} = V_{ub}^* V_{us} U^s + V_{cb}^* V_{cs} C^s$$

$$s \to d: \qquad \mathcal{H}_{\text{eff}}^{\Delta S=0} = V_{ub}^* V_{ud} U^d + V_{cb}^* V_{cd} C^d$$

Decays related by $U(d \leftrightarrow s)$

$$< f|U^s(C^s)|B > = < Uf|U^d(C^d)|UB > \equiv A_u(A_c)$$

$$A(B \to f,\ \Delta S = 1) = V_{ub}^* V_{us} A_u + V_{cb}^* V_{cs} A_c$$

$$A(UB \to Uf,\ \Delta S = 0) = V_{ub}^* V_{ud} A_u + V_{cb}^* V_{cd} A_c$$

$$A(\bar{B} \to \bar{f},\ \Delta S = -1) = V_{ub} V_{us}^* A_u + V_{cb} V_{cs}^* A_c$$

$$A(U\bar{B} \to U\bar{f},\ \Delta S = 0) = V_{ub} V_{ud}^* A_u + V_{cb} V_{cd}^* A_c$$

$$\frac{V_{ub}^* V_{us}}{V_{ub}^* V_{ud}} = -\frac{V_{cb}^* V_{cd}}{V_{cb}^* V_{cs}} = \tan\theta_c$$

Question : 4 rates determine $|V_{ub}^* V_{us} A_u|$, $|V_{cb}^* V_{cs} A_c|$
$\delta \equiv \mathrm{Arg}(A_u A_c^*)$, $\phi_3 \equiv \gamma \equiv \mathrm{Arg}(-V_{ub}^* V_{ud} V_{cb} V_{cd}^*)$???

Answer: Needs additional input

CKM unitarity

$$\mathrm{Im}(V_{ub}^* V_{us} V_{cb} V_{cs}^*) = -\mathrm{Im}(V_{ub}^* V_{ud} V_{cb} V_{cd}^*)$$

implies

Theorem: in the U-spin symmetry limit

$$\Delta\Gamma(B \to f) \equiv |A(B \to f)|^2 - |A(\bar{B} \to \bar{f})|^2 =$$

$$-\Delta\Gamma(UB \to Uf) \equiv -[|A(UB \to Uf)|^2 - |A(U\bar{B} \to U\bar{f})|^2]$$

examples:

$$\Delta\Gamma(B^0 \to K^+\pi^-) = -\Delta\Gamma(B_s \to \pi^+ K^-)$$

$$\Delta\Gamma(B^0 \to K^{*+}\pi^-) = -\Delta\Gamma(B_s \to \rho^+ K^-)$$

$$\Delta\Gamma(B^+ \to K^+\pi^+\pi^-) = -\Delta\Gamma(B^+ \to \pi^+ K^+ K^-)$$

$$\Delta\Gamma(B^+ \to K^{*+}\gamma) = -\Delta\Gamma(B^+ \to \rho^+\gamma)$$

CKM $\Rightarrow$ opposite sign CP asymmetries

U-spin: determining $\phi_3 = \gamma$

$B^0 \to K^+\pi^-$, $B_s \to K^-\pi^+$, $B^+ \to K^0\pi^+$, c.c.

$$A(B^0 \to K^+\pi^-) = V_{ub}^* V_{us} A_u + V_{cb}^* V_{cs} A_c$$

$$A(B_s \to \pi^+ K^-) = V_{ub}^* V_{ud} A_u + V_{cb}^* V_{cd} A_c$$

$$A(\bar{B}^0 \to K^-\pi^+) = V_{ub} V_{us}^* A_u + V_{cb} V_{cs}^* A_c$$

$$A(\bar{B}_s \to \pi^- K^+) = V_{ub} V_{ud}^* A_u + V_{cb} V_{cd}^* A_c$$

$$\Gamma(B_s \to K^-\pi^+) - \Gamma(\bar{B}_s \to K^+\pi^-) =$$

$$-[\Gamma(B^0 \to K^+\pi^-) - \Gamma(\bar{B}^0 \to K^-\pi^+)]$$

additional input for γ: $\Gamma(B^\pm \to K_S\pi^\pm)$

neglect rescattering (no "Tree" $\propto V_{ub}^* V_{us}$)

$$A(B^+ \to K^0\pi^+) = A(B^- \to \bar{K}^0\pi^-) = V_{cb}^* V_{cs} A_c$$

$$R \equiv \frac{\Gamma(B^0 \to K^\pm \pi^\mp)}{\Gamma(B^\pm \to K\pi^\pm)} \qquad R_s \equiv \frac{\Gamma(B_s \to K^\pm \pi^\mp)}{\Gamma(B^\pm \to K\pi^\pm)}$$

$$\mathcal{A}_0 \equiv \frac{\Delta(B^0 \to K^+ \pi^-)}{\Gamma(B^\pm \to K\pi^\pm)} \qquad \mathcal{A}_s \equiv \frac{\Delta(B_s \to K^- \pi^+)}{\Gamma(B^\pm \to K\pi^\pm)}$$

$$r \equiv |V_{ub}^* V_{us} A_u| / |V_{cb}^* V_{cs} A_c|$$

$$\delta_{K\pi} \equiv \mathrm{Arg}(A_u A_c^*)$$

$$\gamma \equiv \mathrm{Arg}(-V_{ub}^* V_{ud} V_{cb} V_{cd}^*)$$

$$R = 1 + r^2 + 2r \cos\delta_{K\pi} \cos\gamma$$

$$R_s = \tan\theta_c^2 + (r/\tan\theta_c)^2 - 2r\cos\delta_{K\pi}\cos\gamma$$

$$\mathcal{A}_0 = -\mathcal{A}_s = -2r \sin\delta_{K\pi} \sin\gamma$$ *checks* $SU(3)$

$SU(3)$ *breaking* (factorization):

$$f = F_{B_s K}(m_\pi^2) f_\pi / F_{B\pi}(m_K^2) f_K$$

$$\mathcal{A}_s = -f^2 \mathcal{A}_0$$

Tevatron Run II: $\delta(\gamma) \sim 10^\circ$

Another example of U-spin for $\phi_3 \equiv \gamma$ $(R.Fleischer)$

$$B^0(t) \to \pi^+\pi^-,\ B_s(t) \to K^+K^-$$

measure

$$Asym(t) \equiv A_{\text{mix}} \sin(\Delta m t) + A_{\text{dir}} \cos(\Delta m t)$$

for $B^0 \to \pi^+\pi^-$ and $B_s \to K^+K^-$

Four quantities in terms of $|P/T|_{\pi\pi}$, δ, β, γ.

Tevatron Run II: $\delta(\gamma) \sim 10°$

Flavor SU(3) in $B, B_s \to \pi\pi, K\pi, K\bar{K}$ (rescattering)

$A \equiv \langle (PP)_{\text{S-wave}} | \text{effective Hamiltonian} | B_{u,d,s} \rangle$

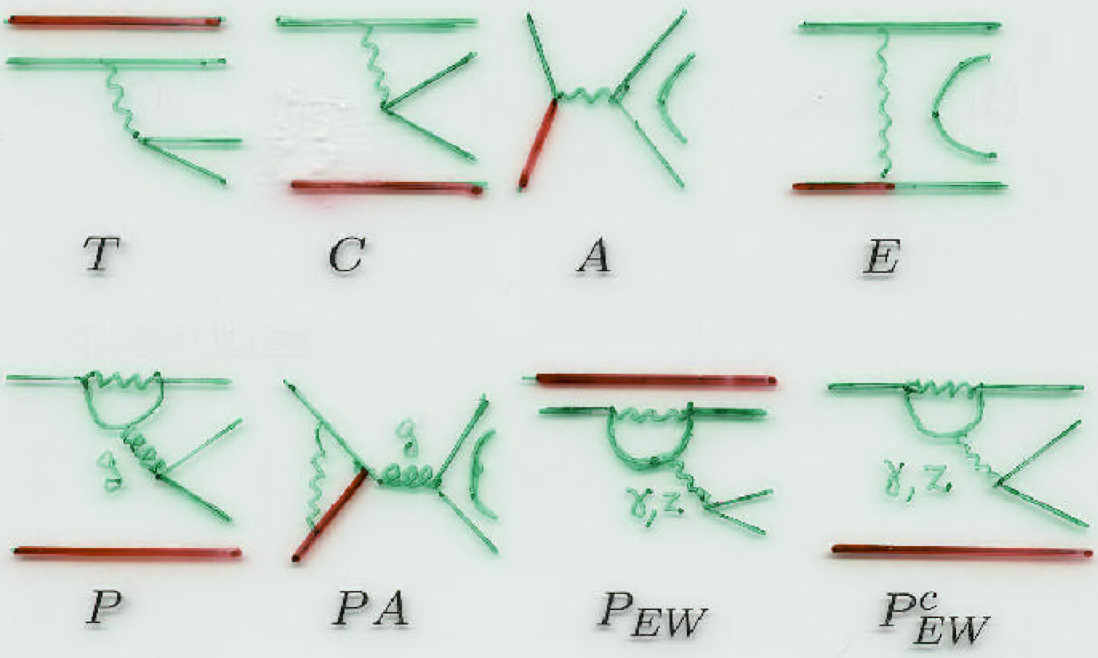
$(8 \otimes 8)_{\text{sym}} = \mathbf{1} + \mathbf{8} + \mathbf{27} \qquad \overline{\mathbf{3}} + \mathbf{6} + \overline{\mathbf{15}} \qquad \mathbf{3}$

5 SU(3) reduced matrix elements:

$\langle 1 \| \overline{3} \| 3 \rangle \quad \langle 8 \| \overline{3} \| 3 \rangle \quad \langle 8 \| 6 \| 3 \rangle \quad \langle 8 \| \overline{15} \| 3 \rangle \quad \langle 27 \| \overline{15} \| 3 \rangle$

equivalent to 8 diagrams in 5 combinations

occurring with given CKM factors



EW penguin $\propto$ Tree

- "Tree" operators, Q_1 and Q_2: $(V-A)(V-A)$
- EW penguin operators with **dominant** c_i, Q_9 and Q_{10}: $(V-A)(V-A)$

$\Rightarrow$ EWP and Tree operators transforming as given SU(3) representations are proportional to each other

$$\frac{\mathcal{H}_{EWP}^{(\Delta S=1)}(\overline{15})}{\mathcal{H}_{Tree}^{(\Delta S=1)}(\overline{15})} = -\frac{3}{2}\frac{c_9 + c_{10}}{c_1 + c_2}\frac{V_{tb}^* V_{ts}}{V_{ub}^* V_{us}}$$

$$= -(0.65 \pm 0.15)\ e^{-i\gamma} \equiv -\delta_{EW}\ e^{-i\gamma}$$

$\Rightarrow$ Hadronic matrix elements are related and involve a common strong phase

Example: $B^+ \to K^0\pi^+, K^+\pi^0$

Where does only $\overline{\mathbf{15}}$ contribute? $B \to (K\pi)_{I=3/2}$

$$A(B^+ \to K^0\pi^+) + \sqrt{2}A(B^+ \to K^+\pi^0) \;=\; <\overline{\mathbf{15}}>$$

$$-(T + C + P_{EW} + P^c_{EW}) = -(T + C)(1 - \delta_{EW}\ e^{-i\gamma})$$

Tree and EWP are subdominant

Dominant penguin $\in \mathbf{3}$ are equal ($\Delta I = 0$) in

$A(B^+ \to K^0\pi^+)$ and $-\sqrt{2}A(B^+ \to K^+\pi^0)$

$$R_*^{-1} \equiv \frac{2\Gamma(B^\pm \to K^\pm\pi^0)}{\Gamma(B^\pm \to K^0\pi^\pm)}$$

$$\frac{|R_*^{-1} - 1|}{2\epsilon} \leq |\cos\gamma - \delta_{EW}| \qquad (\delta_{EW} = 0.65 \pm ...)$$

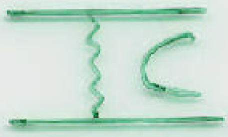
$$\epsilon = \sqrt{2}\frac{V_{us}}{V_{ud}}\frac{f_K}{f_\pi}\frac{|A(B^+ \to \pi^0\pi^+)|}{|A(B^+ \to K^0\pi^+)|} = 0.20 \pm 0.05$$

[also $A(B^+ \to \pi^+\pi^0) \;=\; <|\overline{\mathbf{15}}|> \;\propto\; T + C$]

$(R_*^{-1})_{ave} = 1.45 \pm 0.46 \;\neq\; 1\ ??? \Rightarrow \gamma \;\neq\; \sim 50^\circ$

Final state rescattering

No Tree amplitude:

- $A(B^0 \to K^+K^-) = PA + E$ 

  Is E small $\propto f_B/m_B$? How large is rescattering

  $$B^0 \to \pi^+\pi^-, \rho^+\rho^- \to K^+K^- \quad ?$$

  No rescattering: $\mathcal{B}(B^0 \to K^+K^-) = n \times 10^{-8}$

  Present limit $\mathcal{B}(B^0 \to K^+K^-) < 1.9 \times 10^{-6}$ needs improvement

- $A(B^+ \to K^0\pi^+) = (P - \frac{1}{3}P^c_{EW}) + A$ 

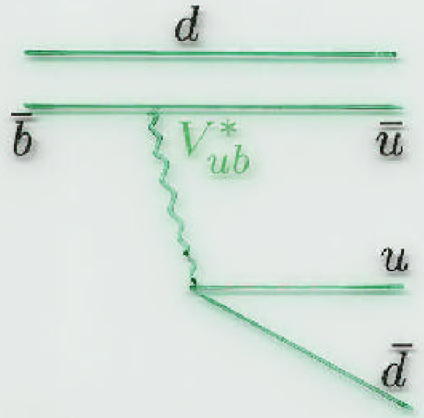
  Is A small $\propto f_B/m_B$? How large is rescattering

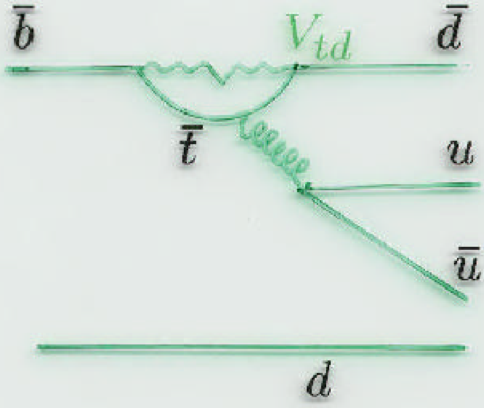
  $$B^+ \to K^+\pi^0, K^{*+}\rho^0 \to K^0\pi^+ \quad ?$$

$$A(B^+ \to \bar{K}^0K^+) = -(P - \frac{1}{3}P^c_{EW})\tan\theta_c + A\tan^{-1}\theta_c$$

enhancement by $\tan^{-2}\theta_c \approx 20$ of A/P ratio in $B^+ \to \bar{K}^0K^+$ relative to $B^+ \to K^0\pi^+$ can be measured

- $B^0(t) \to \pi^+\pi^-$: **Penguin Pollution**





$V_{ub}^* V_{ud} < T >$ $\qquad$ $V_{tb}^* V_{td} \frac{\alpha_s}{12\pi} \ln \frac{m_t^2}{m_b^2} < P >$

phase γ $\qquad$ phase $-\beta$

CLEO '98: $K\pi/\pi\pi$: $\frac{\text{Penguin}}{\text{Tree}} \sim 0.3 \pm 0.1$

$$A(t) \equiv a_{\text{dir}} \cos(\Delta m t) + \sqrt{1 - a_{\text{dir}}^2} \sin 2(\alpha + \theta) \sin(\Delta m t)$$

direct CP violation $\qquad$ **penguin pollution**

$$a_{\text{dir}} \sim \frac{\text{Penguin}}{\text{Tree}} \sin\delta \qquad \theta \sim \frac{\text{Penguin}}{\text{Tree}} \cos\delta$$

$$\delta \equiv \text{Arg}(P/T)$$

- **solution 1: Isospin symmetry**

  $B^0(t) \to \pi^+\pi^-,\ B^+ \to \pi^+\pi^0,\ B^0 \to \pi^0\pi^0, C.C.$

  - P is pure $\Delta I = 1/2 \ \Rightarrow I(\pi\pi) = 0$
  - $T \propto P^{EW} \ \Rightarrow I(\pi\pi) = 2$

  Isospin triangle resolves penguin pollution

  Difficulty: $B^0 \to \pi^0\pi^0$ is color-suppressed $BR < 10^{-6}$ (if little rescattering $B \to D^+D^-, \pi^+\pi^- \to \pi^0\pi^0$)

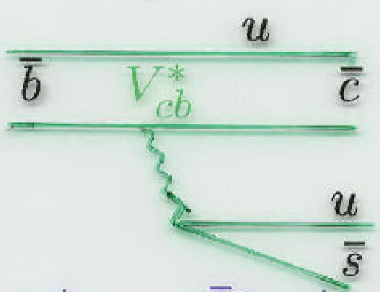
  $$\sin(\delta\alpha) \leq \sqrt{\frac{\mathcal{B}(B \to \pi^0\pi^0)}{\mathcal{B}(B^\pm \to \pi^\pm\pi^0)}} \quad (Grossman, Quinn)$$

- **solution 2: Calculate $|P/T|$ ($\delta = \mathrm{Arg}(P/T)$)**

  - $a_{\mathrm{dir}}, a_{\mathrm{mix}}$ = functions of $(|P/T|, \delta, \beta, \gamma)$
  - after measurement of β, measurement of $a_{\mathrm{dir}}, a_{\mathrm{mix}}$ determines δ and γ

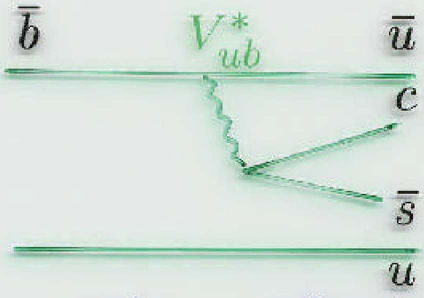
- **New physics** $(D.\ London)$

- $B^{\pm} \to DK^{\pm}$ **measures** $\sin\gamma$ **precisely**



$B^{+} \to \bar{D}^{0} K^{+}$

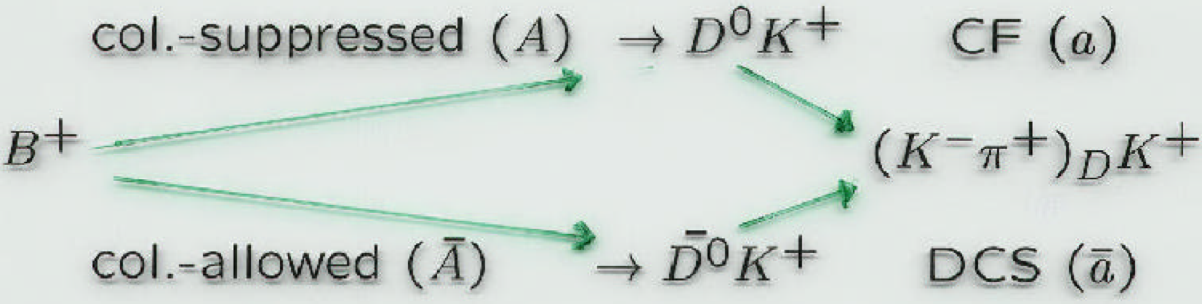
color-allowed ($\bar{A}$)



$B^{+} \to D^{0} K^{+}$

color-suppressed (A)

(1) D^0 **flavor modes**: $D^0 \to K^{-}\pi^{+}$



$$\Gamma \equiv \Gamma(B^{+} \to (K^{-}\pi^{+})_D K^{+}) = |Aa|^2 + |\bar{A}\bar{a}|^2$$

$$+ 2|A\bar{A}a\bar{a}| \cos(\delta_{DK} + \Delta_{K\pi} + \gamma)$$

$$\bar{\Gamma} \equiv \Gamma(B^{-} \to (K^{+}\pi^{-})_D K^{-}) = \Gamma(\gamma \to -\gamma)$$

$$\frac{\bar{\Gamma} - \Gamma}{\bar{\Gamma} + \Gamma} = \frac{2|\bar{A}\bar{a}Aa| \sin(\delta + \Delta) \sin\gamma}{|Aa|^2 + |\bar{A}\bar{a}|^2 + 2|A\bar{A}a\bar{a}| \cos(\delta + \Delta) \cos\gamma}$$

maximal for $|\bar{A}\bar{a}/Aa| = 1$, $\delta + \Delta = \pi/2$

measured $\bar{A}, a, \bar{a}$:

$$|\bar{A}|^2 \propto \mathcal{B}(B^+ \to \bar{D}^0 K^+) = (2.9 \pm 0.8) \times 10^{-4}$$

$$|a|^2 \propto \mathcal{B}(D^0 \to K^-\pi^+) = (3.83 \pm 0.09) \times 10^{-2}$$

$$|\bar{a}|^2 \propto \mathcal{B}(\bar{D}^0 \to K^-\pi^+) = (1.46 \pm 0.30) \times 10^{-4}$$

$$\frac{|\bar{a}|}{|a|} = 0.062 \pm 0.007 \;=\; (1.21 \pm 0.13)\tan^2\theta_c$$

$$= \;\tan^2\theta_c \quad \mathrm{U-spin}$$

not measured: $A, (\delta_{DK} + \Delta_{K\pi}), \gamma$

$$\frac{|A|}{|\bar{A}|} \sim \frac{|V^*_{ub}V_{cs}|}{V^*_{cb}V_{us}|}\frac{|a_2|}{|a_1|} \sim 0.1 \quad \Rightarrow \quad \frac{|\bar{A}\bar{a}|}{|Aa|} \sim 0.6$$

$\delta_{DK} =?$ probably small, as in $B \to D\pi$

$$\Delta_{K\pi} \;\equiv\; \mathrm{Arg}\frac{A(D^0 \to K^-\pi^+)}{A(\bar{D}^0 \to K^-\pi^+)} = \;?$$

$$= \;0 \quad \mathrm{U-spin}, \quad \mathrm{estimate} < 20^\circ$$

$\Rightarrow$ sizable asymmetry cannot be excluded

$\Gamma(B^\pm \to (K\pi)_D K^\pm) =$ functions of $A, (\delta + \Delta), \gamma$

determination of γ requires another DCS mode

$\bar{D}^0 \to K^-\pi^+\pi^0$ $(K^*\pi,\ K\rho)$ (*A. Smith*)

(2) D^0 **CP modes**: $D^0_+ \to K^+K^-$

$$D^0_{+,-} = \frac{1}{\sqrt{2}}(D^0 \pm \bar{D}^0)$$

$$\sqrt{2}A(B^+ \to D^0_\pm K^+) = \pm|\bar{A}| + |A| \exp[i(\delta + \gamma)] \quad .$$

$$R_\pm \equiv \frac{2[\Gamma(B^+ \to D^0_\pm K^+) + C.C.}{\Gamma(B^+ \to \bar{D}^0 K^+) + C.C.}$$

$$\mathcal{A}_\pm \equiv \frac{\Gamma(B^+ \to D^0_\pm K^+) - C.C.}{\Gamma(B^+ \to \bar{D}^0 K^+) + C.C.} \quad .$$

$$R_\pm = 1 + |A/\bar{A}|^2 \pm 2|A/\bar{A}| \cos\delta \cos\gamma$$
$$\mathcal{A}_- = -\mathcal{A}_+ = |A/\bar{A}| \sin\delta \sin\gamma$$

Three equations for $|A/\bar{A}|$, δ, γ

$$1 + |A/\bar{A}|^2 = (R_+ + R_-)/2$$

cannot measure $|A/\bar{A}| \sim 0.1$ precisely

$\sin^2\gamma \leq R_\pm \Rightarrow$ new constraint on γ

e.g.: $\gamma = 40°$, $\frac{|A|}{|\bar{A}|} = 0.1$, $\delta = 0 \Rightarrow R_- = 0.85$

10^8 B^+B^- pairs: $\delta(R_-) = 0.05$

$\Rightarrow$ $73° < \gamma < 107°$ excluded at 90% c.l.

- combine D^0 CP modes and D^0 flavor modes

(*Atwood, Dunietz, Soni*)

(*Soffer*)

- measure $\sin(2\beta+\gamma)$ in $B^0(t) \to D^{*0}K^{*0}$ through time and angular dependence involving interference of helicity amplitudes

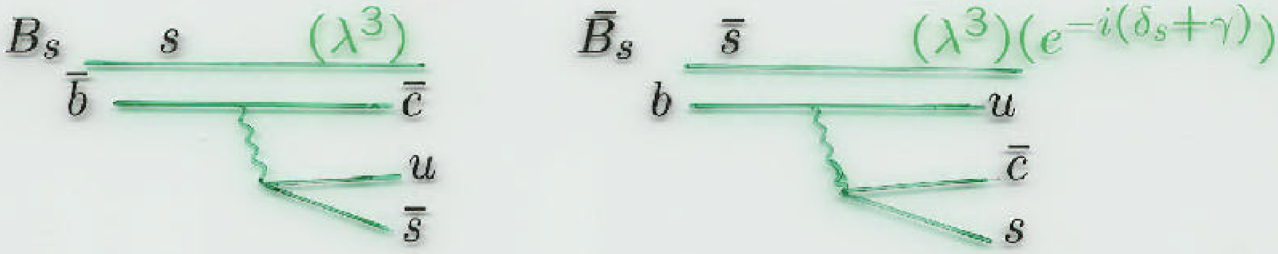
(*London, Sinha*[2])

- $\mathcal{B}(B^+ \to \bar{D}^0 K^+)\mathcal{B}(\bar{D}^0 \to K^-\pi^+) = (4.2\pm1.4)\times 10^{-8}$ $\Rightarrow$ **method requires** $> \mathcal{O}(10^8) B\bar{B}$ **pairs**

(*D. Atwood*)

- $B_s(t) \to D_s K$ **measures** $\sin\gamma$

(1) flavor tagged B_s time-dependence (*Dunietz et al*)



$|B_s>$ → $\cos(\Delta m t/2)|B_s>$ $\quad A_s(\bar{b} \to \bar{c}u\bar{s})$ → $|D_s^- K^+>$

$|B_s>$ → $i\sin(\Delta m t/2)|\bar{B}_s>$ $\quad \bar{A}_s(b \to u\bar{c}s)$ → $|D_s^- K^+>$

$$\Gamma(B_s(t) \to D_s^- K^+) = e^{-\Gamma_s t}[|A_s|^2 \cos^2(\frac{\Delta m t}{2})$$
$$+ \; |\bar{A}_s|^2 \sin^2(\frac{\Delta m t}{2}) - |A_s \bar{A}_s| \sin(\delta_s + \gamma) \sin(\Delta m t)]$$

$$(a)\ \Gamma(B_s(t) \to D_s^- K^+) = f(|A_s|,\ |\bar{A}_s|,\ \delta_s + \gamma)$$
$$(b)\ \Gamma(\bar{B}_s(t) \to D_s^+ K^-) = f(\gamma \to -\gamma)$$
$$(c)\ \Gamma(\bar{B}_s(t) \to D_s^- K^+) = f(|A_s| \leftrightarrow |\bar{A}_s|)$$
$$(d)\ \Gamma(B_s(t) \to D_s^+ K^-) = f(|A_s| \leftrightarrow |\bar{A}_s|, \gamma \to -\gamma)$$

this determines γ

(2) Untagged $B_s(t)$ including $\frac{\Delta\Gamma_s}{\Gamma_s} \sim 10\%$

$$\Gamma(B_s(t) \to D_s^- K^+) + \Gamma(\bar{B}_s(t) \to D_s^- K^+) = \frac{1}{2}(|A_s|^2 + |\bar{A}_s|^2)(e^{-\Gamma_L t} + e^{-\Gamma_H t}) + |A_s \bar{A}_s| \cos(\delta_s + \gamma)(e^{-\Gamma_L t} - e^{-\Gamma_H t})$$

$$\Gamma(B_s(t) \to D_s^+ K^-) + \Gamma(\bar{B}_s(t) \to D_s^+ K^-) : \gamma \to -\gamma$$

2 rates determine γ for known $|A_s|$

($|A_s|$ obtained from tagged B_s or factorization)

(3) CP-tagged B_s time-integrated (*Falk*)

$B_s^{CP+} = (B_s + \bar{B}_s)/\sqrt{2}$ $\qquad$ $B_s^{CP+} \to D_s^+ D_s^-$

$$A(B_s^{CP+} \to D_s^- K^+) = [|A_s| + |\bar{A}_s| e^{-i(\delta_s+\gamma)}]/\sqrt{2}$$

$$A(B_s^{CP+} \to D_s^+ K^-) = [|A_s| + |\bar{A}_s| e^{-i(\delta_s-\gamma)}]/\sqrt{2}$$

two triangles determine γ

requires independent measurement of $|A_s|$, $|\bar{A}_s|$

CP-tagged $B_s^{CP+} \to D_s^+ K^-$ can be measured at a very high luminosity e^+e^- B factory on $\Upsilon(5S)$

conclusions

- Measure crudely many CP asymmetries

$$\Delta(B^0 \to K^+\pi^-) = -\Delta(B_s \to \pi^+K^-)$$

$$\Delta(B^0 \to \pi^+\pi^-) = -\Delta(B_s \to K^+K^-)$$

relative signs test CKM (U-spin)

- Measure precisely certain charge-averaged rates

$$\frac{\Gamma(B^\pm \to K^\pm\pi^0)}{\Gamma(B^\pm \to K\pi^\pm)}, \quad \frac{\Gamma(B^\pm \to D^0_{CP}K^\pm)}{\Gamma(B^\pm \to D^0_{FL}K^\pm)}$$

constrain $\phi_3 \equiv \gamma$

- Measure precisely certain CP asymmetries

$$B \to \pi\pi,\ K\pi,\ DK, \quad B_s \to K\pi,\ K\bar{K},\ D_sK$$

determine $\phi_3 \equiv \gamma$ precisely

- Improve theory of hadronic B decays (*Brodsky, Li, Keum, Sanda, Silvestrini*)

calculate P/T, SU(3) breaking, rescattering

questions can be studied experimentally