$\boxed{\text{Novel}}$ Effects in B System: From Intrinsic Charm to SUSY *

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I. Intro: Learning from CLEO History

Hardware/Software/Statistics $\Longleftrightarrow$ NewPhysics/Unfolding/NewTricks

Be Prepared for New Discoveries/Phenomena!

⋆⋆⋆ Era of BaBar/Belle and Tevatron Competition ⋆⋆⋆

II. New Physics Signals

1 A. Generic bsg Dipole: $\sin 2\phi_{\phi K_S}$ 1

B. Flavor Symmetry ⊕ SUSY: 2

2 B.1. d-b Mixing: Low $\sin 2\Phi_{B_d}$ and D^0 Mixing? 4

3 B.2. s-b Mixing: Δm_{B_s}, $\sin 2\Phi_{B_s}$; (D^0 Mixing); light $\widetilde{sb}$ 1

III. Rare Baryons: New Pathways?

4 A. New Tricks: $B \to \eta' \mathsf{B}_s \bar{\mathsf{B}}$, $\gamma \mathsf{B}_s \bar{\mathsf{B}}$ (Control: $B \to D^* N \bar{N}$) 3

5 B. Standard Two Body (Unfolding, Shear Statistics) 1

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V. Other: ϕ_3/γ; ϕ_2/α; PT, PS; Direct A_{CP}; EWP ...

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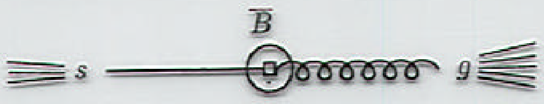
*Report on recent work w/ Abdes Arhrib, Chia-Hung Chang, Chun-Khiang Chua, Amarjit Soni, Shang-Yuu Tsai, and Kwei-Chou Yang.
Also earlier work w/ N.G. Deshpande, Ben Tseng, Xiao-Gang He, and Sandip Pakvasa.

II. New Physics Signals: Where Large?

A. Generic *bsg* Dipole ... $\sin 2\phi_{\phi K_S}$

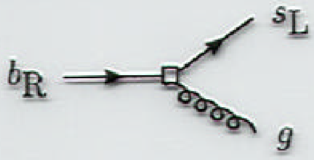
♡ H^+ cannot enhance, but squark-gluino loops (Kagan/Ciuchini)!

▷ $b \to sg$ leads to *jetty, high multiplicity* $b \to s$ transitions



Hide easily in dominant $b \to c \to s$ sequence!

▷ New CP phase via $b_R \to s_L$ *Unconstrained*



Phase of b_R not probed by V_{CKM}!

$|c_{11}| \, e^{i\sigma}$

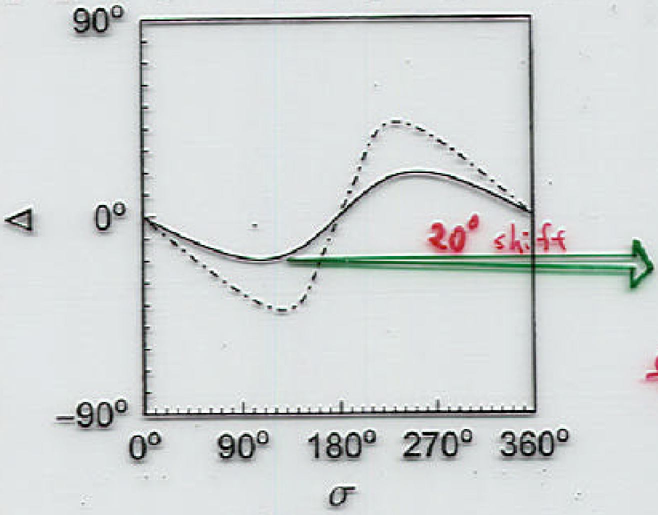
♣ Late 1997 Rumor of $A_{CP} \sim 100\%$ evaporated ca. 1999:(

This diminishes, but does not eliminate, Prospects (w/ K.C. Yang):

▷ Direct CP in $B \to \phi K$ May still be sizable

▷▷ Mixing-dep. CP Very Interesting:

$\Delta = \phi_{\phi K_S} - \phi_{J/\psi K_S}$



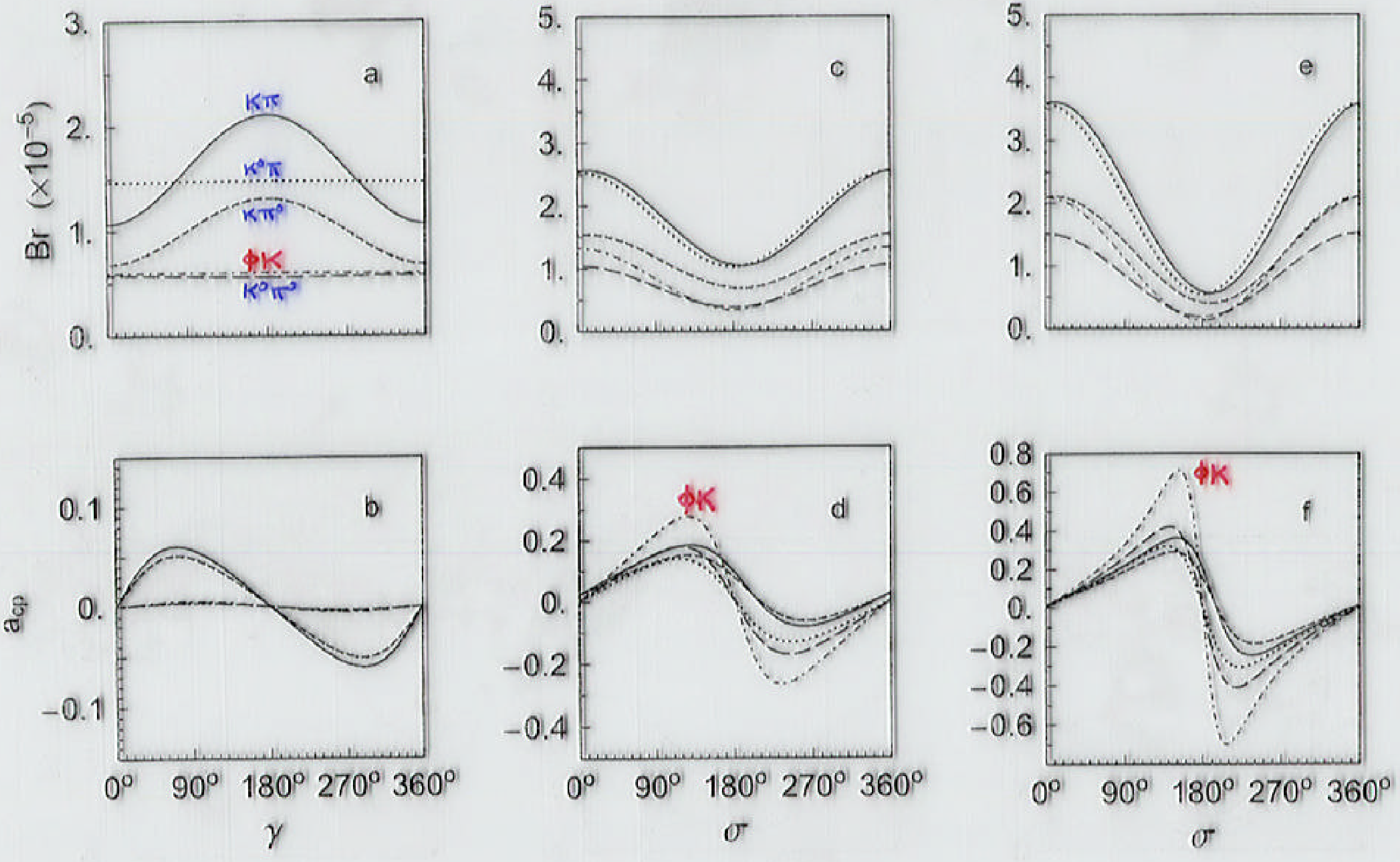
$\sin 2\phi_{\phi K_S} \simeq 0.93$

for $\sin 2\phi_{B_d \to J/\psi K_S} = 0.48$

Dotdash/solid for $b \to sg \simeq 10\%/2.5\%$

Hard to Rule Out

$b \to sg \sim 2.5\%$ 10%



B. Generic Abelian Flavor Symmetry with SUSY

New Physics in Flavor Sector is likely since little is understood.

Mass/Mixing Hierarchy: Intriguing pattern in powers of $\lambda \equiv |V_{us}|$

$$\begin{cases} m_u/m_c \sim \lambda^3, \quad m_c/m_t \sim \lambda^4, \\ m_d/m_s \sim \lambda^2, \quad m_s/m_b \sim \lambda^2, \quad m_b/m_t \sim \lambda^3, \\ |V_{cb}| \sim \lambda^2, \qquad |V_{ub}| \sim \lambda^3. \end{cases}$$

Since $V_{\rm CKM} = U_L^\dagger D_L$, so $U_L,\ D_L \sim V$ Natural;

So,

L

$$\frac{M_u}{m_t} \sim \begin{bmatrix} \lambda^7 & \lambda^5 & \lambda^3 \\ ? & \lambda^4 & \lambda^2 \\ ? & ? & 1 \end{bmatrix}, \quad \frac{M_d}{m_b} \sim \begin{bmatrix} \lambda^4 & \lambda^3 & \lambda^3 \\ ? & \lambda^2 & \lambda^2 \\ ? & ? & 1 \end{bmatrix}.$$

R

Lower left of mass matrices diagonalized by $\boxed{U_R,\ D_R}$ Unknown

Possible underlying ("horizontal" or flavor) Symmetry?

$\rightsquigarrow$ Breaking gives expansion in $\lambda \sim \langle S \rangle / M$,

S a scalar field and M a high scale.

[E.g. Froggat-Nielsen '79]

Abelian Horizontal Symmetry: Commuting Horizontal Charges

$$\rightsquigarrow \boxed{M_{ij} M_{ji} \sim M_{ii} M_{jj}} \quad (i,\, j \text{ not summed}),$$

hence [Nir-Seiberg '93; Leurer-Nir-Seiberg '94]

$$\frac{M_u}{m_t} \sim \begin{bmatrix} \lambda^7 & \lambda^5 & \lambda^3 \\ \lambda^6 & \lambda^4 & \lambda^2 \\ \lambda^4 & \lambda^2 & 1 \end{bmatrix}, \quad \frac{M_d}{m_b} \sim \begin{bmatrix} \lambda^4 & \lambda^3 & \lambda^3 \\ \lambda^3 & \lambda^2 & \lambda^2 \\ \lambda & 1 & 1 \end{bmatrix}.$$ Inferred

31 32

N.B.: $\boxed{M_d^{32}/m_b,\ M_d^{31}/m_b}$ are Most Prominent off-diagonal elements

$\rightsquigarrow$ Impact on B_d and B_s Mixings Naturally

IFF Right-Handed Down Sector can be Heard.

How? Well hidden in SM!

No R-dynamics

Enter SUSY: $\tilde{d}_R$ Couples to $\tilde{g}$ $\tilde{d}_R$-$\tilde{g}$ Loops

Take squarks as *almost* degenerate at scale $\widetilde{m}$ (customary)

Squark mixing angle in quark mass basis is

$$\delta^{ij}_{qAB} \cong [U^\dagger_{qA}(\widetilde{M}^2_q)_{AB}U_{qB}]^{ij}/\widetilde{m}^2, \qquad (A, B = L, R)$$

Since $U_{qL} \sim V_{\rm CKM}$, while

$$U_{qR} \sim \begin{pmatrix} 1 & \lambda & \lambda \\ \lambda & 1 & 1 \\ \lambda & 1 & 1 \end{pmatrix}$$

If Flavor symmetry and SUSY breakings not closely related, then

▷ $(\widetilde{M}^2_q)^{ij}_{LR} \sim \widetilde{m}\, M^{ij}_d$, $\quad (\widetilde{M}^2_q)_{RL} = (\widetilde{M}^2_q)^\dagger_{LR}$

i.e. Both *roughly* $\propto$ quark mass matrices (Yukawa source)

$\rightsquigarrow$ Effects suppressed by $m_q/\widetilde{m}$.

▷ $(\widetilde{M}^2_Q)_{LL} \sim \widetilde{m}^2 V_{CKM}$, but

$$(\widetilde{M}^2_d)_{RR} \sim \widetilde{m}^2 \begin{bmatrix} 1 & \lambda & \lambda \\ \boxed{\lambda} & 1 & 1 \\ \lambda & 1 & 1 \end{bmatrix}.$$

$\tilde{d}_R$-$\tilde{b}_R \sim \lambda$

$\tilde{s}_R$-$\tilde{b}_R \sim 1$

$[\tilde{d}_R$-$\tilde{s}_R \sim \lambda]$

▷ $\boxed{RR\ \text{Sector}}$ contribute significantly to B_d (or B_s) Mixings

Note also the strength of $(\widetilde{M}^2_d)^{12}_{RR}$

Generic Flavor Symmetry/Violation can impact on Measurables via SUSY!

⋆ The Flavor/CP Violation are on Same Footing as $V_{\rm CKM}$.

$L \Rightarrow R$ sector

B.1. d-b Mixing: Low $\sin 2\Phi_{B_d}$ and D^0 Mixing?

[C.K. Chua and WSH, hep-ph/00 05 015, to appear in PRL]

RR sector could contribute significantly to B_d mixing via $\delta^{13}_{dRR} \sim \lambda$; Large

LR and RL mixings are suppressed by $m_q/\widetilde{m}$.

Effective Hamiltonian (gluino-squark box diagrams)

[Chargino and neutralino boxes numerically unimportant]

$$H^{\tilde{g}}_{\rm eff} = -\frac{\alpha_s^2}{216\tilde{m}^2}(C_1\mathcal{O}_1 + \tilde{C}_1\tilde{\mathcal{O}}_1 + C_4\mathcal{O}_4 + C_5\mathcal{O}_5)$$

where ($\tilde{C}_1\tilde{\mathcal{O}}_1$ obtained from $C_1\mathcal{O}_1$ by $L \to R$)

$$\mathcal{O}_1 = \bar{q}^\alpha_L\gamma_\mu b^\alpha_L\,\bar{q}^\beta_L\gamma^\mu b^\beta_L,$$

$$\mathcal{O}_4 = \bar{q}^\alpha_L b^\alpha_R\,\bar{q}^\beta_R b^\beta_L, \quad \mathcal{O}_5 = \bar{q}^\alpha_L b^\beta_R\,\bar{q}^\beta_R b^\alpha_L.$$

with ($x \equiv m^2_{\tilde{g}}/\widetilde{m}^2$; f_6 and $\tilde{f}_6$ from Gabbiani et al. '96)

$$C_1 = [24\,x f_6(x) + 66\tilde{f}_6(x)]\,(\delta^{i3}_{LL})^2,$$

$$C_{4,5} \cong [504(24)\,x f_6(x) + (-72)(+120)\tilde{f}_6(x)]\,\delta^{i3}_{LL}\delta^{i3}_{RR},$$

$$\Longrightarrow \quad \boxed{M^B_{12} \equiv |M^B_{12}|\,e^{2i\phi_B} = |M^{\rm SM}_{12}|\,e^{2i\boxed{\phi_1}} + |M^{\rm SUSY}_{12}|\,e^{i\boxed{\phi_{\rm SUSY}}}}$$

Experiment measure ϕ_B may not be ϕ_1/β of CKM!

Numerical Evaluation w/ SUSY

- SM: Take $|V_{ub}| = 0.41|\lambda V_{cb}|$, $\overset{\gamma}{\phi_3} = 65^\circ, 85^\circ$, $\rightsquigarrow |V_{td}| \times 10^3 = 8.0, 9.2$

  $\Longrightarrow \Delta m^{\rm SM}_{B_d} \sim 0.41, 0.55\,{\rm ps}^{-1}$,

  vs. $\Delta m^{\rm exp}_{B_d} = 0.472 \pm 0.017\,{\rm ps}^{-1}$ (PDG; Belle similar)

  Well known that SM $\Delta m^{\rm SM}_{B_d} \equiv |M^{\rm SM}_{12}|$ Sufficient for $\Delta m^{\rm exp}_{B_d}$.

- Allowing $|M^{\rm SUSY}_{12}|$ at most of similar size

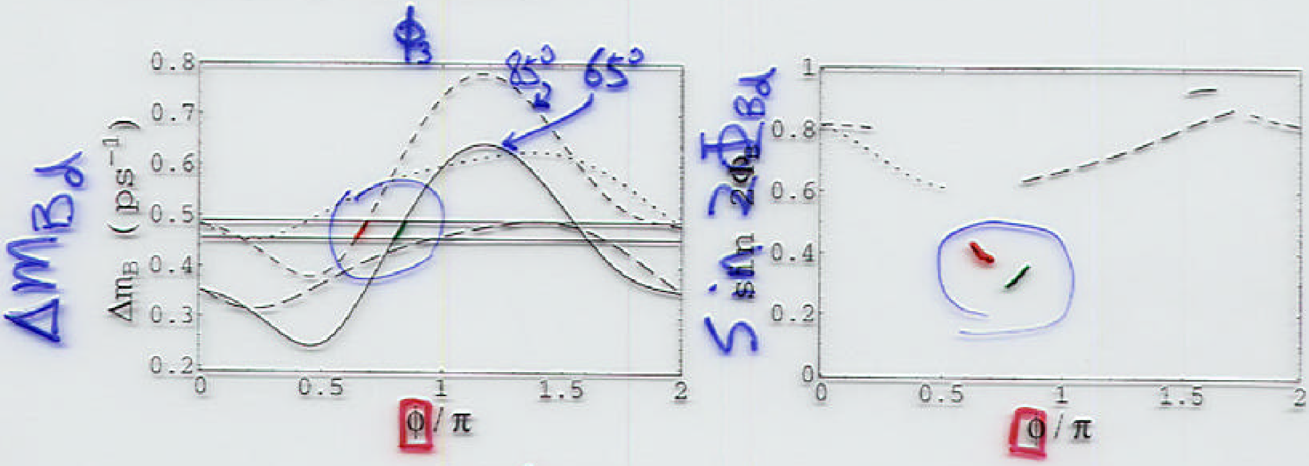
  $\Longrightarrow$ $m_{\tilde{q}} \sim \widetilde{m}$, $m_{\tilde{q}}$ cannot be much lighter than 1.5 $\boxed{\text{TeV}}$!

  since $\delta^{13}_{dRR} \sim \lambda$ vs. $V_{td} \sim \lambda^3$

$m_{\rm SUSY} \sim \frac{1}{\alpha} M_W^2 \sim \text{TeV}$

Illustration

Δm_{B_d} and $\sin 2\phi_{B_d}$ vs. $\boxed{\phi \equiv \arg \delta^{13}_{dRR}}$, including both SM and SUSY effects, for squark mass $\widetilde{m} = 1.5$ TeV (and $\tan\beta = 2$ and $|\mu| < m_{\tilde{g}}$).
Horizontal double lines indicate 2σ experimental range.
Solid (short-dash), long-dash (dotted) curves for $m_{\tilde{g}} = 1.5$, 3 TeV and $\phi_3 = 65^\circ$ (85°), respectively.



SUSY $\tilde{d}_R - \tilde{b}_R$ phase

before ICHEP2000

So, $\sin 2\phi_{B_d}$ via $J/\psi K_S$ can range from 0.3 (stated 5/2000!) to 1
vs. $\sin 2\phi_1 \simeq 0.75$–0.71 for $\phi_3 = 65^\circ$–85° in SM

$\boxed{\text{Low } \sin 2\phi_{B_d} \sim 0.3\text{–}0.4 \text{ possibility of particular interest}}$

Compared to BaBar and Belle central values. 0.48 ± 0.16 World

$\rightsquigarrow$ *CKM unitarity bound from $\Delta m_{B_s}/\Delta m_{B_d}$ should be relaxed*

$\rightsquigarrow$ Potential conflict on ϕ_3 w.r.t. Charmless Rare B may be alleviated

N.B. With $\widetilde{m}$, $m_{\tilde{g}} \gtrsim$ TeV and $(\widetilde{M}^2_q)_{LR,RL}$ suppressed by $m_q/\tilde{m}$

$\Longrightarrow$ Little impact on penguins

$\Longrightarrow$ Charmless B Decays better access to CKM phases
(except hadronic uncertainty)

Await Summer Results!

Δm_K, ε_K Constraint: Alignment

Severe

Too Naive so far: Δm_K and ε_K Much More Stringent

$\rightsquigarrow$ Impossible to sustain $\delta^{12}_{dLL,RR} \sim \lambda$, even with $\widetilde{m}$, $m_{\tilde{g}} \gtrsim$ TeV

$\rightsquigarrow$ Invoke $\boxed{\text{Quark-Squark Alignment}}$ (QSA) to Impose "Texture Zeros"

$\rightsquigarrow$ Two Singlets S_i break $U(1) \times U(1)$ Abelian horizontal symmetry

$\rightsquigarrow$ $M_d^{12,21} = 0$ Possible $\rightsquigarrow$ $\boxed{U^{12}_{dL,R} = 0}$ (or highly suppressed)

$\rightsquigarrow$ $\delta^{12}_{dLL,RR}$ can be suppressed $\rightsquigarrow$ kaon mixing constraint satisfied

Subtlety: From choice of $M_d^{31} \neq 0$, if retain $M_d^{23,32}$

$\rightsquigarrow$ $M_d^{12,21}$ again generated!

Upshot: If Choose to keep $(\widetilde{M}_d^2)^{13}_{RR}/\widetilde{m}^2 \sim \lambda$

$\Longrightarrow$ M_d^{23} *and* M_d^{32} both set to zero $\rightsquigarrow$ Decouple s flavor from d, b

$\Longrightarrow$ No New Physics Effects in B_s Mixing and $b \to s\gamma$ Decays!

Observation: Stringent Δm_K and ε_K Constraints

$\rightsquigarrow$ $\boxed{\text{4 Texture Zeros in } M_d}$

4 Texture Zeros

COMPARE: Besides $M_d^{12,21} = 0$

▷ Usual QSA: M_d^{31} and M_d^{32} Dropped to satisfy B_d mixing and $b \to s\gamma$

$\Longrightarrow$ Allow Lower $m_{\tilde{q}}$, $m_{\tilde{g}}$ for Collider and other signatures

▷ Considered Decoupling d flavor (non-QSA) before [Chua-He-WSH, '99]

$\Longrightarrow$ Again 4 texture zeros (with $b \to s$ phenomenology)

♥ Will touch upon Decoupling d flavor w/ QSA briefly.

D^0-$\bar{D}^0$ Mixing: general consequence of QSA!

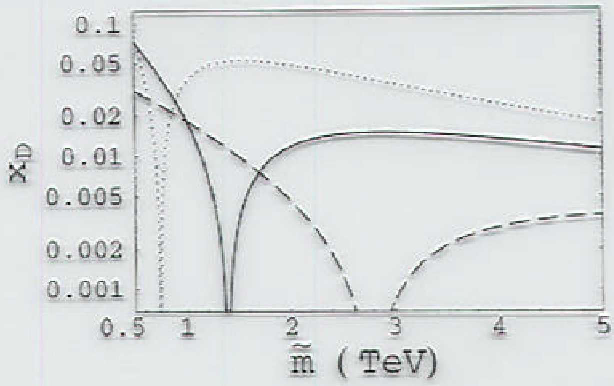
$D_L^{12} \simeq 0$ implies $\boxed{U_L^{12} \sim |V_{ed}| = \lambda}$, $\Longrightarrow$ Generate D^0–$\bar{D}^0$ Mixing

V_{CKM}^{12}

since $\delta_{uLL}^{12} \sim \lambda$ Large $\tilde{u}_L$-$\tilde{c}_L$ $\sim \lambda$

For $m_{\tilde{g}} = 0.8$ (dots), 1.5 (solid) and 3 (dash) TeV ($\tan\beta = 2$):

[The Zero reflects cancellation when common phase, which is unlikely]



$x_D \sim 0.01$ Hint

♡ Recent Tantalizing Hints from Experiment:

▷ CLEO '00: 1.8σ Effect on $y'_D = y_D \cos\delta_D - x_D \sin\delta_D$
$-5.8\% < y'_D < 1\%$; $x'^2_D < 0.082\%$
$(x_D \equiv \Delta m_D/\Gamma_D,\ y_D \equiv \Delta\Gamma_D/\Gamma_D)$

▷ FOCUS '00: 2.2σ $\tau(D^0 \to K^-K^+)/\tau(D^0 \to K^-\pi^+) \neq 1$
$y_{CP} = 0.0342 \pm 0.0139 \pm 0.0074$

INTRIGUING:

- Two Results Better Reconciled if $\delta_D \neq 0$ $\rightsquigarrow$ Hint of x_D?

  [δ_D is relative strong phase btwn $D^0 \to K^+\pi^-$ and $K^-\pi^+$ amplitudes]

- $\delta_{uLL}^{12} \sim \lambda$ with $\tilde{m}$, $m_{\tilde{g}} \sim$ TeV

  $\rightsquigarrow$ *Brings x_D right into ballpark of present sensitivities!*

  $\Longrightarrow$ Belle/BaBar Search!!

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[Further followup on generic Φ_{B_d}, $\pi\pi$ and $\rho\gamma$ discussion, see Poster of C.K. Chua]

Chua

SUSY in $\sin 2\Phi_{B_d}$, $B \to \pi\pi$

Strange-Beauty Squark

B.2. s-b Mixing: Δm_{B_s}, $\sin 2\Phi_{B_s}$; (D^0 Mixing;) **light $\widetilde{sb}$**

[A. Arhrib (see his Poster), C.K. Chua and WSH, to be submitted]

Arhrib #9

Previous d-b mixing case satisfy Δm_K, ε_K by construction (Alignment),

Still have interesting/measurable effects in B_d and D^0 mixings

even if SUSY breaking at TeV scale

Reason: Large $\tilde{d}_R$-$\tilde{b}_R$ and $\tilde{u}_L$-$\tilde{c}_L$ mixings ($\sim \lambda$)

$\Longleftarrow$ From Abelian Horizontal Charges and L.E. Constraints.

Unfortunately,

TeV

- SUSY scale so high $\rightsquigarrow$ Practically No Impact on Penguins such as ε'/ε, $b \to s\gamma$ and $b \to d\gamma$
- Depressing: Squarks/gluino cannot be produced at Tevatron or LHC. No impact on B_s System!

Heavy $\tilde{q}, \tilde{g}$

Any Hope for other Phenomena?

♥ s-b Mixing: Decoupling d flavor w/ QSA

$$(\widetilde{M}_d^2)_{RR} \sim \widetilde{m}^2 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 1 & 1 \end{bmatrix}.$$

$\tilde{s}_R - \tilde{b}_R \sim 1!$

with 4 texture zeros analgous to d-b case.

★ **$\widetilde{sb}_1$ Driven Light by Large s-b Mixing!**

Intrigue

▷ Penguins still little affected

$b \to s\gamma$ quite accommodating in presence of large s-b mixing!

$\Longrightarrow$ $\widetilde{sb}_1$ and $\tilde{\chi}^0$ as light as 100 GeV ALLOWED!

▷ Impact on **B_s Mixing and $\sin 2\Phi_{B_s}$**, w/ or w/o $\widetilde{sb}_1$ Light (scale up B_d)

▷ Collider Signature Change: $\boxed{\widetilde{sb}_1 \to s/b + \tilde{\chi}_1^0}$ (Flavor Mixed!)

Affects "$\tilde{b}$" Search

III. Rare Baryons: New Pathways?

A. New Tricks: $B \to \eta' \mathbf{B}_s \bar{\mathbf{B}}$, $\gamma \mathbf{B}_s \bar{\mathbf{B}}$ (**Control: $B \to D^* N \bar{N}$**)

Many charmless mesonic $B \to M_{(s)} \bar{M} \gtrsim 10^{-5}$ emerged since 1997. CLEO 200

▷ Rare baryonic modes? Less fruitful!

$$B \to \bar{\Lambda} p,\ \bar{\Lambda} p \pi^-,\ \bar{p} p < 0.26,\ 1.3,\ 0.7 \times 10^{-5} \quad (\text{CLEO98},\ 5.8\text{M } B\bar{B})$$

▷ Rare baryonic Theory ($\mathbf{B}$ stands for baryon) equally sparse (handful!),

Where is Best Place to Search for Charmless Baryonic?

Observation: $\boxed{\text{Smallness of } B \to \bar{\mathbf{B}}_{(s)} \mathbf{B} \text{ rooted in Large Energy Release,}}$

Aggravated by more complicated composition of
Baryons (qqq) vs. Mesons ($q\bar{q}$).

Insight: Where Charmless Baryonic B Decays May be Larger?

$\rightsquigarrow$ 1 *Reduced Energy Release* [WSH and A. Soni, hep-ph/0008079]

$\oplus$ *allow for* 2 *Baryonic Ingredients in final state.* Under Appeal @ PRL

Natural starting points:

▷ Inclusive $B \to \eta' + X_s$: Large rate $\sim 6 \times 10^{-4}$ for $p_{\eta'} > 2.0$ GeV

▷ Inclusive $B \to \gamma + X_s$: Large rate $\sim 2 \times 10^{-4}$ for $p_\gamma \gtrsim 2.0$ GeV

Both Processes have η'/γ carry away Large Energy

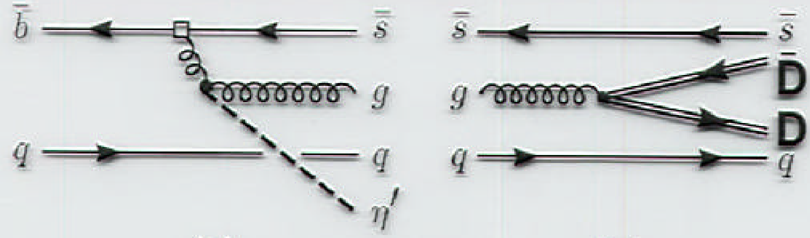
$\Longrightarrow$ Reduced Energy Release within Recoil System X_s!

[**FLASH: CLEO** *Summer 2000*: $B \to D^{*-} N \bar{N}(\pi) \sim 10^{-3}$ …

[hep-ex/0009011] Including $p\boxed{\bar{n}}$

Anomaly motivated

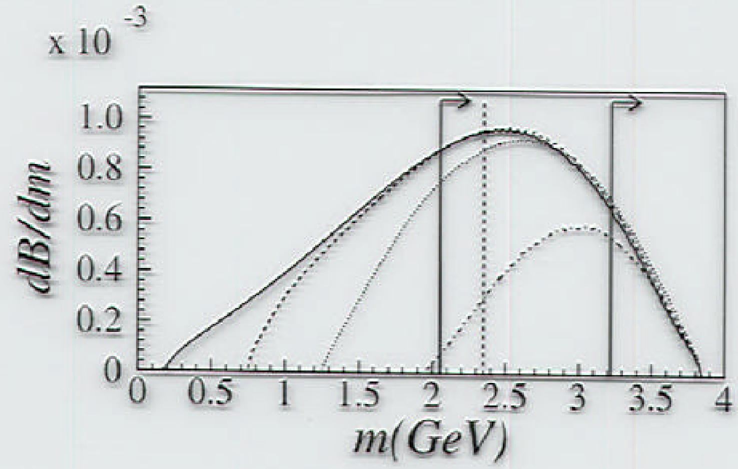
★ Inclusive Picture of (Charmless) Baryon Formation:



(a) (b)

D is Diquark

Illustration for phase space argument of $\bar{B} \to \eta' + sg\bar{q} \to \eta' \mathbf{B}_{(s)} \bar{\mathbf{B}} (\pi)$



Solid, dash, dots, dotdash
$\sim m_g = 0,\ 0.6,\ 1.1,\ 1.8$ GeV
in phase space

Since $\bar{\mathbf{D}}\mathbf{D}$ Pairs already appear to right of $m_g \sim 1.1$ GeV,
Since $\bar{\Lambda}N$ threshold open only at 2.05 GeV

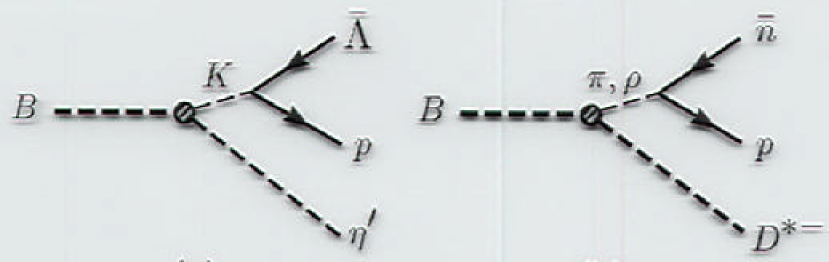
$\Longrightarrow$ Threshold Enhancement for $sg\bar{q} \to \mathbf{B}_{(s)} \bar{\mathbf{B}} (\pi)$
around $m_{X_s} \sim 2.3$ GeV (Cut on $K + n\pi$ Partial Reconstruction) *Likely*

$\boxed{\text{Modes to search for: } \bar{B} \to \eta' \Lambda \bar{N}}$ (and similar low lying $\bar{\mathbf{B}}_s\mathbf{B}$ states)
with Relatively Fast η'

Reconstruction Easy/Low Background ($\Lambda_c^+ \bar{N}$ threshold at 3.22 GeV).

$\Longrightarrow$ May offer Important Probe into Higher Mass m_{X_s} Spectrum!

More detailed study: CLEO $B \to D^{*-} N\bar{N}(\pi)$ Data Improved [Tsai] w/ Tsai /Chu



(a) (b)

Analogous!

♡ Using $B \to D^*$ F.F. and Proton F.F. Data (so Vector Current only)

$\Longrightarrow$ Account for $\sim \frac{1}{2}$ Observed Rate! Other ½ Axial?

$\rightsquigarrow$ Other Half through Axial-vector (e.g. a_1) Channel?

▷ Extend to $B \to \eta' \bar{\Lambda} p$ to $\gamma \bar{\Lambda} p$ (even $\ell \nu \bar{N} N$?)

Caution: Not Same: Not Analogous to Proton F.F. So, Larger?

$\Longrightarrow$ $\eta' \bar{\Lambda} p$; $\gamma \bar{\Lambda} p \sim 10^{-5} > \bar{\Lambda} p$ plausible

$\boxed{\textit{First Charmless Baryon Mode}}$!?

Extra Bonus: $\Lambda \to p\pi$ Decay self-analyze Λ pin

$\rightsquigarrow$ *Probe $B \to \eta'$, γ dynamics* (and CP/T).

☆ For example,

$\kappa_{\bar{\Lambda}} = \boldsymbol{s}_{\bar{\Lambda}} \cdot (\boldsymbol{p}_p \times \boldsymbol{p}_{\bar{\Lambda}})$, $\kappa_{\Lambda} = \boldsymbol{s}_{\Lambda} \cdot (\boldsymbol{p}_p \times \boldsymbol{p}_{\Lambda})$ both T-odd.

So, $\Delta_{\text{odd, even}} = \kappa_{\bar{\Lambda}} \mp \kappa_{\Lambda}$ CP-odd, even ...

$\Longrightarrow$ May uncover New Physics in the long run!

Triple Products

B. Standard Two Body (Unfolding, Shear Statistics)

Traditional Search for $B \to \bar{\mathbf{B}}_{(s)}\mathbf{B}$ 2-body Modes Should Continue!

My original starting point in late 1998 ...

Improve on original Ball-Dosch Diquark work by including Penguins: w/ C.H.V. Chang

Channel	Decay rate	Ball-Dosch	Sum Rule
Normalize $\bar{B}^0 \to p\bar{p}$	1	1	1
$\bar{B}^0 \to n\bar{n}$	1	1	1
$\bar{B}^0 \to \Lambda\bar{n}$	2.0×10^{-1}	3.69×10^{-2}	
$\bar{B}^0 \to \Sigma^0\bar{n}$	2.0×10^{-1}	3.74×10^{-2}	
$\bar{B}^0 \to \Sigma^+\bar{p}$	8.1×10^{-1}	1.50×10^{-1}	3.8
$B^- \to \Lambda\bar{p}$	1.20×10^{-1}	0	≈ 1.9
$B^- \to \Sigma^0\bar{p}$	1.20×10^{-1}	0	1.9
$\bar{B}^0 \to \Lambda\bar{\Lambda}$	3.89×10^{-1}	3.89×10^{-1}	
$\bar{B}^0 \to \Xi\bar{\Lambda}$	3.1×10^{-1}	5.87×10^{-2}	

$\bar{B}^0 \to \Sigma^+\bar{p}$ Comparable, but not large than, $\bar{B}^0 \to p\bar{p}$

[Compare $K\pi$ vs. $\pi\pi$]

Long Way to Go,

but soon?

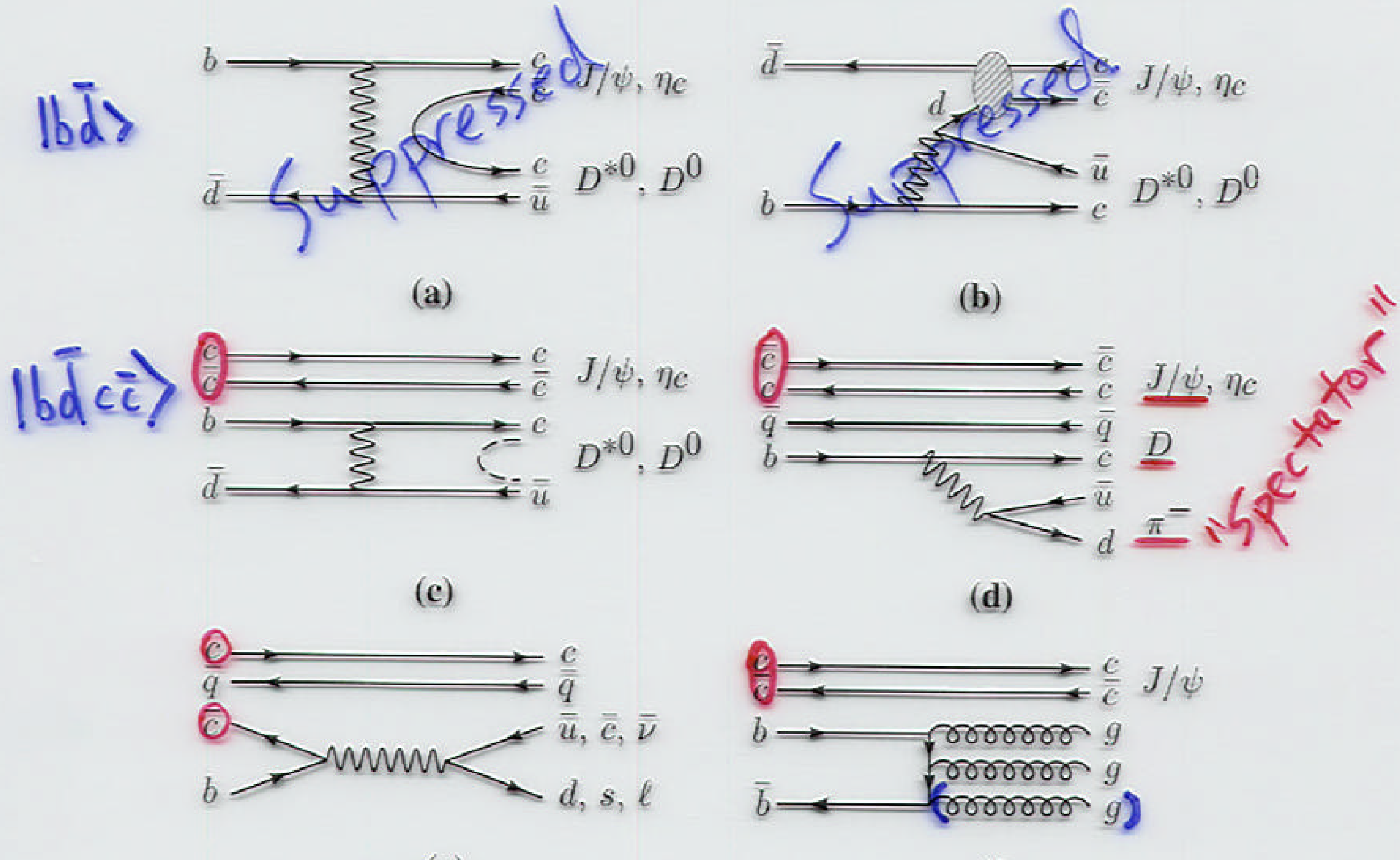
100M $B\bar{B}$

IV. Intrinsic Charm: $\boxed{B \to J/\psi\, D\pi!?}$ Smoking Gun?

or Red Herring

$b \to c\bar{c}c$!!
Effective

[C.H.V. Chang and WSH]
hep-ph/0101162



$\Upsilon \longrightarrow J/\psi + X$.

$\bar{B}^0 \to J/\psi D^{(*)0}$ via

(a) exchange and

(b) OZI violating (blob) rescattering;

$\bar{B}^0 \to J/\psi D^{(*)0}$ and $\bar{B} \to J/\psi D\pi^-$ from $\boxed{|b\bar{d}c\bar{c}\rangle \text{ Fock component}}$ via

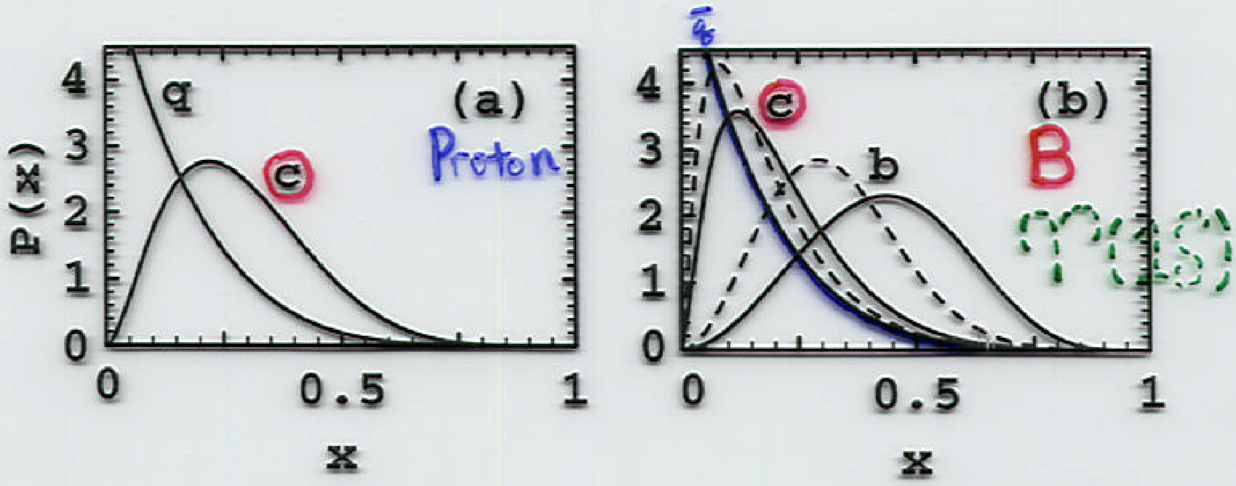
(c) exchange and

(d) spectator diagrams

(e) $b\bar{c}$ annihilation in $|b\bar{d}c\bar{c}\rangle$ Fock component;

(f) $\Upsilon(1S) \to J/\psi + X$ production via $|b\bar{b}c\bar{c}\rangle$ Fock component.

Distributions



Intrinsic charm (arbitrary normalization) in
(a) proton and
(b) B meson (b and $\bar{q}$ distributions also shown).
Dashed line in (b) are for the $|b\bar{b}\, c\bar{c}\rangle$ component of $\Upsilon(1S)$.

$\boxed{\text{Strength}}$? Larger Fraction than in Light Hadrons!

▷ Analysis of EMC Data (Harris, Smith and Vogt 1996) $\Longrightarrow$ IC $\sim 0.86\%$!

▷ Since $|uudc\bar{c}\rangle$ Fock component of $p \sim$ fluctuation on "borrowed E" $\propto (m_p^2/M_{uudc\bar{c}}^2)^2$

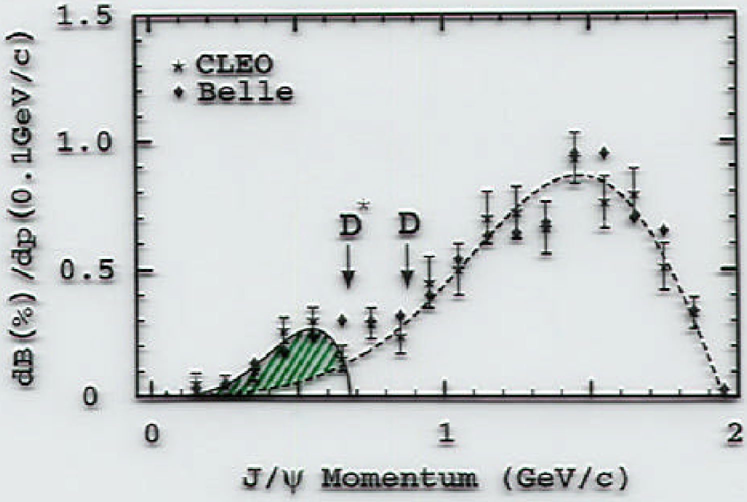
$\Longrightarrow$ *IC $|b\bar{q}\; c\bar{c}\rangle$ LARGER in B Meson* $\propto (m_B^2/M_{b\bar{q}\,c\bar{c}}^2)^2$

Better Bank to borrow from.

In any case, Heavy Mesons Smaller, so, Higher Frequency Components.

Published ICHEP2000

Hint from CLEO & Belle Inclusive J/ψ Data



simple fit

Inclusive $B \to J/\psi + X$ with $B \to \psi' + X$ and $\chi_c + X$ feed-down subtracted. The stars CLEO published while diamonds are from Belle ICHEP2000. Curves are simple modified phase space fit, with solid for excess below 0.9 GeV assuming $D\pi$ recoil starting at 0.66 GeV. D and D^* recoil thresholds are indicated.

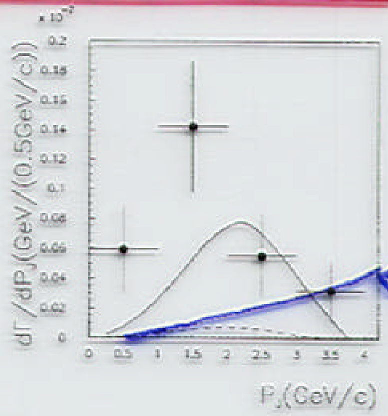
$\sim 4 \times 10^{-4}$ ← Can Argue for

Suggest $B \to J/\psi\, D\pi$ could be of order 10^{-3}. Search Easy.

▷ Possible Explanation for Soft Spectrum for $\Upsilon(1S) \Rightarrow J/\psi + X$.

Note $p_{J/\psi}$ Spectrum Peak ~ 1.5 GeV.

Rather Soft.



color octet & PQCD

▷ Suggest Possibility of $B_c \Rightarrow J/\psi\, J/\psi\, \pi$.

SAME VERTEX

$\Longrightarrow$ $\boxed{\text{Smoking Gun Evidence (Finally) for IC, } \textit{at B-Factories?}}$

Amusing!

"New Physics" As "New Tricks" from Old.

Be Prepared

for

New Discoveries/Phenomena

?