Novel Effects in B System:
From Intrinsic Charm to SUSY

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I. Intro: Learning from CLEO History

Hardware/Software/Statistics ↔ NewPhysics/Unfolding/NewTricks

Be Prepared for New Discoveries/Phenomena!

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

II. New Physics Signals

A. Generic $b \to s g$ Dipole: $\sin 2\phi_{K^0}$

B. Flavor Symmetry $\oplus$ SUSY:
   - d-b Mixing: Low $\sin 2\Phi_{D_s}$ and $D^0$ Mixing?
   - s-b Mixing: $\Delta m_{B_s}$, $\sin 2\Phi_{B_s}$; ($D^0$ Mixing); light $s_b$

III. Rare Baryons: New Pathways?

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

B. Standard Two Body (Unfolding, Shear Statistics)

IV. Intrinsic Charm: $J/\psi D\pi$ Flabbergasting New Trick?

V. Other: $\phi_3/\gamma$; $\phi_2/\alpha$; PT, PS; Direct $A_{CP}$; EWP ...

*Report on recent work w/ Abdes Arhrib, Chia-Hung Chang, Chua-Khiang Chua, Amarjit Soni, Shang-Yuan 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

\[ \begin{array}{c}
\text{Hide easily in dominant} \\
\text{sequence!}
\end{array} \]

- New CP phase via $b_R \to s_L$ Unconstrained

\[ e^{1i\Delta} \]

- 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:

\[ \Delta = \phi_{bsg} - \phi_{bqK_s} \]

\[ \Delta = 0^\circ \]

\[ \Delta = 90^\circ \]

\[ \Delta = -90^\circ \]

\[ \Delta = 180^\circ \]

\[ \Delta = 270^\circ \]

\[ \Delta = 360^\circ \]

\[ \sin 2\phi_{\phi K_s} \approx 0.93 \]

\[ \sin 2\phi_{B_s \to \phi K_s} \approx 0.48 \]

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

Hard to Rule Out
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 $\lambda \equiv |V_{us}|$

\[
\begin{align*}
\frac{m_u}{m_c} &\sim \lambda^3, \quad \frac{m_d}{m_s} \sim \lambda^2, \\
\frac{m_c}{m_t} &\sim \lambda^4, \quad \frac{m_s}{m_b} \sim \lambda^2, \\
|V_{cb}| &\sim \lambda^2, \quad |V_{ub}| \sim \lambda^3.
\end{align*}
\]

Since $V_{CKM} = U^T_D D_L$, so $U_L, D_L \sim V$ Natural:

So,

\[
\begin{align*}
\frac{M_u}{m_l} &\sim \begin{bmatrix} \lambda^7 & \lambda^5 & \lambda^3 \\ \lambda^6 & \lambda^4 & \lambda^2 \\ 1 & 1 & 1 \end{bmatrix}, \\
\frac{M_d}{m_b} &\sim \begin{bmatrix} \lambda^4 & \lambda^3 & \lambda^3 \\ \lambda^2 & \lambda^2 & \lambda^2 \\ 1 & 1 & 1 \end{bmatrix}.
\end{align*}
\]

Possible underlying ("horizontal" or flavor) Symmetry?

\[\sim\] 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

\[M_{ij} M_{ji} \sim M_{ii} M_{jj}\]

(i, j not summed).

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

\[
\begin{align*}
\frac{M_u}{m_l} &\sim \begin{bmatrix} \lambda^7 & \lambda^5 & \lambda^3 \\ \lambda^6 & \lambda^4 & \lambda^2 \\ 1 & 1 & 1 \end{bmatrix}, \\
\frac{M_d}{m_b} &\sim \begin{bmatrix} \lambda^4 & \lambda^3 & \lambda^3 \\ \lambda^2 & \lambda^2 & \lambda^2 \\ 1 & 1 & 1 \end{bmatrix}.
\end{align*}
\]

N.B.: $M_{d3}^{32}/m_b, M_{d3}^{31}/m_b$ are Most Prominent off-diagonal elements

\[\sim\] 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 $\tilde{g}$

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

Squark mixing angle in quark mass basis is

$$\delta_{q_{AB}}^{ij} \equiv \left[ U_{qA}^\dagger (\tilde{M}_q^2)_{AB} U_{qB} \right]^{ij} / \tilde{m}^2, \quad (A, B = L, R)$$

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

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

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

$\sim$ Effects suppressed by $m_q / \tilde{m}$.

$$(\tilde{M}_Q^2)_{LL} \sim \tilde{m}^2 V_{CKM}, \text{ but } \quad (\tilde{M}_d^2)_{RR} \sim \tilde{m}^2 \begin{bmatrix} 1 & \lambda & \lambda \\ \lambda & 1 & 1 \\ \lambda & 1 & 1 \end{bmatrix}.$$

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

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

$$(\tilde{M}_d^2)_{RR} \sim \tilde{m}^2 \begin{bmatrix} \alpha & 1 & 1 \\ \alpha & 1 & 1 \\ \alpha & 1 & 1 \end{bmatrix}.$$
B.1. $d$-$b$ Mixing: Low sin $2\Phi_{B_d}$ and $D^0$ Mixing?


$\delta_{dRR}^{13} \sim \lambda$  

Large

$RR$ sector could contribute significantly to $B_d$ mixing via $LR$ and $RL$ mixings are suppressed by $\frac{m_u}{m}$.  

**Effective Hamiltonian (gluino-squark box diagrams)**

[Chargino and neutralino boxes numerically unimportant]

$$H_{\text{eff}}^q = -\frac{\alpha_s^2}{216m^2}(C_1\mathcal{O}_1 + \tilde{C}_1\tilde{\mathcal{O}}_1 + C_4\mathcal{O}_4 + C_5\mathcal{O}_5)$$

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

$$\mathcal{O}_1 = q^0_L \gamma^\mu b^0_L \bar{q}^0_L \gamma^\mu b^0_L,$$

$$\mathcal{O}_4 = q^0_L b^0_R q^0_R b^0_L, \quad \mathcal{O}_5 = \tilde{q}^0_L b^0_R \tilde{q}^0_R \tilde{b}^0_L.$$

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

$$C_1 = [24xf_6(x) + 66\tilde{f}_6(x)](\delta_{LL}^{13})^3.$$

$$C_{4,5} \equiv [504(24)xf_6(x) + (-72)(+120)\tilde{f}_6(x)]\delta_{LL}^{13}\delta_{RR}^{13}.$$

$$\Rightarrow \frac{M_{B_d}^P}{\left|M_{B_d}^S\right|} e^{2i\phi_P} = \left|M_{B_d}^{12}\right| e^{2i\phi_1} + \left|M_{B_d}^{12\text{SM}}\right| e^{2i\phi_{12\text{SM}}}. $$

**Experiment measure $\phi_B$ may not be $\phi_1/\beta$ of CKM!**

**Numerical Evaluation w/ SUSY**

- **SM:** Take $|V_{ub}| = 0.41|\lambda V_{ub}|, \ \phi_2 = 65^\circ, 85^\circ, \Rightarrow |V_{td}| \times 10^3 = 8.0, 9.2$

  $$\Rightarrow \Delta m_{B_d}^{\text{SM}} \sim 0.41, 0.55 \text{ ps}^{-1},$$

  vs. $\Delta m_{B_d}^{\text{exp}} = 0.472 \pm 0.017 \text{ ps}^{-1}$  (PDG; Belle similar)

  **Well known that SM $\Delta m_{B_d}^{\text{SM}} \equiv |M_{12}^{12}\text{SM}|$ Sufficient for $\Delta m_{B_d}^{\text{exp}}$.**

- **Allowing $|M_{12}^{12\text{SUSY}}|$ at most of similar size

  $$\Rightarrow m_{\tilde{g}} \sim \bar{m}, \ m_{\tilde{g}} \text{ cannot be much lighter than } 1.5 \text{ TeV}!$$

  since $\delta_{dRR}^{13} \sim \lambda$ vs. $V_{ud} \sim \lambda^3$
$\Delta m_{B_d}$ and $\sin 2\phi_{B_d}$ vs. $\phi \equiv \arg \delta_{\text{susy}}^{\text{LR-R}}$, including both SM and SUSY effects, for squark mass $\tilde{m} = 1.5 \text{ TeV}$ (and $\tan \beta = 2$ and $|\mu| < m_\tilde{g}$). Horizontal double lines indicate $2\sigma$ experimental range. Solid (short-dash), long-dash (dotted) curves for $m_\tilde{g} = 1.5, 3 \text{ TeV}$ and $\phi_3 = 65^\circ, 85^\circ$, respectively.

**SUSY $\tilde{t}_R$-$\tilde{b}_R$ phase**

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

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

Compared to BaBar and Belle central values.

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

$\sim$ Potential conflict on $\phi_3$ w.r.t. Charmless Rare $B$ may be alleviated

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

$\Rightarrow$ Little impact on penguins

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

Await Summer Results!
**Severe**

**Alignment**

Too Naive so far: \(\Delta m_K\) and \(\varepsilon_K\) Much More Stringent

\(\sim\) Impossible to sustain \(\delta_{dL,R}^{12}\) \(\sim\) even with \(m, m_\tilde{q} >\) TeV

\(\sim\) Invoke **Quark-Squark Alignment (QSA)** to Impose "Texture Zeros"

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

\(\sim\) \(M_{d}^{12,21} = 0\) Possible \(\sim\) \(U_{dL,R}^{12} = 0\) (or highly suppressed)

\(\sim\) \(\delta_{dL,R}^{12}\) can be suppressed \(\sim\) kaon mixing constraint satisfied

**Subtlety:** From choice of \(M_{d}^{31} \neq 0\), if retain \(M_{d}^{23,32}\)

\(\sim\) \(M_{d}^{12,21}\) again generated!

**Upshot:** If Choose to keep \((M_{d}^{13})_{RR}/m^2 \sim \lambda\)

\(\Rightarrow\) \(M_{d}^{23}\) and \(M_{d}^{32}\) both set to zero \(\Rightarrow\) Decouple flavor from \(d, b\)

\(\Rightarrow\) No New Physics Effects in \(B_s\) Mixing and \(b \rightarrow s\gamma\) Decays!

**Observation:** Stringent \(\Delta m_K\) and \(\varepsilon_K\) Constraints

\(\sim\) **Texture Zeros in \(M_d\)**

**COMPARE:** Besides \(M_{d}^{12,21} = 0\)

\(\Rightarrow\) Usual QSA: \(M_{d}^{31}\) and \(M_{d}^{32}\) Dropped to satisfy \(B_d\) mixing and \(b \rightarrow s\gamma\)

\(\Rightarrow\) Allow Lower \(m_{\tilde{q}}, m_{\tilde{q}}\) for Collider and other signatures

\(\Rightarrow\) Considered Decoupling \(d\) flavor (non-QSA) before [Chiu-He-WSH, '99]

\(\Rightarrow\) Again 4 texture zeros (with \(b \rightarrow s\) phenomenology)

\(\Rightarrow\) Will touch upon Decoupling \(d\) flavor w/ QSA briefly.
$D^0 - \bar{D}^0$ Mixing: general consequence of QSA!

$D_{L}^{12} \approx 0$ implies $U_{L}^{12} \sim |V_{cd}| = \lambda \Rightarrow$ Generate $D^0 - \bar{D}^0$ Mixing

since $\delta_{aLL}^{12} \sim \lambda$

For $m_g = 0.8$ (dots), 1.5 (solid) and 3 (dash) TeV ($\tan \beta = 2$):

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

Recent Tantalizing Hints from Experiment:

$\triangleright$ CLEO '00: $1.8\sigma$ Effect on $y_D = y_D \cos \delta_D - x_D \sin \delta_D$

$-5.8\% < y_D < 1\%; \quad x_D^2 < 0.082\%$

$(x_D \equiv \Delta m_D / \Gamma_D, \; y_D \equiv \Delta \Gamma_D / \Gamma_D)$

$\triangleright$ FOCUS '00: $2.2\sigma$ $\tau(D^0 \to K^- K^+)/\tau(D^0 \to K^- \pi^+) \neq 1$

$y_{\text{CP}} = 0.0342 \pm 0.0139 \pm 0.0074$

INTRIGUING:

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

[\(\delta_D\) is relative strong phase b/w $D^0 \to K^+ \pi^-$ and $K^- \pi^+$ amplitudes]

- $\delta_{aLL}^{12} \sim \lambda$ with $\bar{m}, \; m_\bar{g} \sim \text{TeV}$

$\sim$ Brings $x_D$ right into ballpark of present sensitivities!

$\Rightarrow$ Belle/BaBar Search!!

[Further followup on generic $\Phi_{B_s}, \pi\pi$ and $\rho\gamma$ discussion, see Poster of C.K. Chua]
B.2. s-b Mixing: $\Delta m_{B_s}, \sin 2\Phi_{B_s}; (D^0\text{ Mixing})$ light $sb$

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

Previous $d-b$ mixing case satisfy $\Delta m_K, \varepsilon_K$ by construction (Alignment),
Still have interesting/measurable effects in $B_d$ and $D^0$ mixings.
even if SUSY breaking at TeV scale

Reason: Large $\bar{d}R\bar{b}_R$ and $\bar{u}_R\bar{c}_L$ mixings ($\sim \lambda$)
From Abelian Horizontal Charges and L.E. Constraints.

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

Any Hope for other Phenomena?
- s-b Mixing: Decoupling d flavor w/ QSA

$$(\tilde{M}_3^2)_{RR} \sim \tilde{m}^2 \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$
with 4 texture zeros analogous to $d-b$ case.

$*$ $sb_1$ Driven Light by Large $s-b$ Mixing!

- Penguins still little affected
  $b \rightarrow s\gamma$ quite accommodating in presence of large $s-b$ mixing!
  $\Rightarrow \tilde{s}b_1$ and $\tilde{\chi}^0_1$ as light as 100 GeV ALLOWED!
- Impact on $B_s$ Mixing and $\sin 2\Phi_{B_s}$, w/ or w/o $\tilde{s}b_1$ Light (scale up $B_d$)
- Collider Signature Change: $\tilde{s}b_1 \rightarrow \bar{s}/b + \tilde{\chi}^0_1$ (Flavor Mixed!)

Affects "b" Search
III. Rare Baryons: New Pathways?

- New Tricks: $B \rightarrow \eta' B_s \bar{B}, \gamma B_s \bar{B}$ (Control: $B \rightarrow D^* N \bar{N}$)
  - Many charmless mesonic $B \rightarrow M(m) \bar{M} \gtrsim 10^{-5}$ emerged since 1997.
  - Rare baryonic modes? Less fruitful!
    - $B \rightarrow \bar{A} p, \bar{A} p \pi^-, \bar{p} p < 0.26, 1.3, 0.7 \times 10^{-5}$ (CLEO98, 5.8M $B \bar{B}$)
  - Rare baryonic Theory ($B$ stands for baryon) equally sparse (handful!),

Where is Best Place to Search for Charmless Baryonic?

Observation: Smallness of $B \rightarrow B_{(s)} B$ rooted in Large Energy Release,
  - Aggravated by more complicated composition of Baryons ($qqq$) vs. Mesons ($qq$).
Insight: Where Charmless Baryonic $B$ Decays May be Larger?
  - Reduced Energy Release [WSH and A. Soni, hep-ph/0008079]
  - allow for Baryonic Ingredients in final state.

Natural starting points:
  - Inclusive $B \rightarrow \eta' + X_s$: Large rate $\sim 6 \times 10^{-4}$ for $p_{\eta'} > 2.0$ GeV
  - Inclusive $B \rightarrow \gamma + X_s$: Large rate $\sim 2 \times 10^{-4}$ for $p_\gamma \gtrsim 2.0$ GeV

Both Processes have $\eta'/\gamma$ carry away Large Energy
  $\Rightarrow$ Reduced Energy Release within Recoil System $X_s$!

[FLASH: CLEO Summer 2000: $B \rightarrow D^{* -} N \bar{N}(\pi) \sim 10^{-3}$ ...]
  [hep-ex/0009011] Including $p \bar{p}$
Anomaly motivated

\* Inclusive Picture of (Charmless) Baryon Formation:

(a) \(\bar{b} \rightarrow \bar{s} + q + q\)

(b) \(\bar{s} \rightarrow \bar{s} + g \rightarrow \eta' + g \rightarrow \eta'B_{(s)}\bar{B}(\pi)\)

Illustration for phase space argument of \(\bar{B} \rightarrow \eta' + sg\bar{q} \rightarrow \eta'B_{(s)}\bar{B}(\pi)\)

\[x \times 10^{-3}\]

\[\frac{d\mathcal{B}}{dm}\]

\[m(\text{GeV})\]

Solid, dash, dots, dotdash
\(m_g = 0, 0.6, 1.1, 1.8 \text{ GeV}\)
in phase space

Since \(DD\) Pairs already appear to right of \(m_g \sim 1.1 \text{ GeV}\),
Since \(\Lambda N\) threshold open only at 2.05 GeV
\(\Rightarrow\) Threshold Enhancement for \(sg\bar{q} \rightarrow B_{(s)}\bar{B}(\pi)\)
around \(m_{X_s} \sim 2.3 \text{ GeV}\) (Cut on \(K + n\pi\) Partial Reconstruction) Likely

Modes to search for: \(\bar{B} \rightarrow \eta'\Lambda N\) (and similar low lying \(\bar{B}_sB\) states)
with Relatively Fast \(\eta'\)

Reconstruction Easy/Low Background (\(\Lambda^+\bar{N}\) threshold at 3.22 GeV).
\(\Rightarrow\) May offer Important Probe into Higher Mass \(m_{X_s}\) Spectrum!
More detailed study: CLEO $B \to D^{*-} N \bar{N}(\pi)$ Data Improved

(a) \hspace{2cm} (b)

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

$\Rightarrow$ Account for $\sim \frac{1}{3}$ Observed Rate!

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

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

Caution: Not Same: Not Analogous to Proton F.F.

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

First Charmless Baryon Mode!!?

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

$\sim$ Probe $B \to \eta'$, $\gamma$ dynamics (and $CP/T$).

For example,

$\kappa_A = s_A \cdot (p_p \times p_A)$, $\kappa_A = s_A \cdot (p_p \times p_A)$ both $T$-odd.

So, $\Delta_{odd, even} = \kappa_A \neq \kappa_A$ $CP$-odd, even...

$\Rightarrow$ May uncover New Physics in the long run!
B. Standard Two Body (Unfolding, Shear Statistics)

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

My original starting point in late 1998 ...

Improve on original Ball-Dosch Diquark work by including Penguins:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Decay rate</th>
<th>Ball-Dosch</th>
<th>Sum Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{B}^0 \rightarrow p\bar{p}$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$\bar{B}^0 \rightarrow n\bar{n}$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$\bar{B}^0 \rightarrow \Lambda\bar{\Lambda}$</td>
<td>$2.0 \times 10^{-1}$</td>
<td>$3.69 \times 10^{-2}$</td>
<td>3.8</td>
</tr>
<tr>
<td>$\bar{B}^0 \rightarrow \Sigma^0\bar{\Lambda}$</td>
<td>$2.0 \times 10^{-1}$</td>
<td>$3.74 \times 10^{-2}$</td>
<td>3.8</td>
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<tr>
<td>$\bar{B}^0 \rightarrow \Sigma^+\bar{p}$</td>
<td>$8.1 \times 10^{-1}$</td>
<td>$1.50 \times 10^{-1}$</td>
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<tr>
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<tr>
<td>$B^- \rightarrow \Sigma^0\bar{p}$</td>
<td>$1.20 \times 10^{-1}$</td>
<td>0</td>
<td>1.9</td>
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<tr>
<td>$B^0 \rightarrow \Lambda\Lambda$</td>
<td>$3.89 \times 10^{-1}$</td>
<td>$3.89 \times 10^{-1}$</td>
<td>3.8</td>
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<tr>
<td>$B^0 \rightarrow \Xi\Lambda$</td>
<td>$3.1 \times 10^{-1}$</td>
<td>$5.87 \times 10^{-2}$</td>
<td>3.8</td>
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</tbody>
</table>

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

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

Long Way to Go, but soon?

100M $\bar{B}^0$
IV. Intrinsic Charm: or Red Herring

\[ \bar{B}^0 \rightarrow J/\psi D^{(*)0} \] via
(a) exchange and
(b) OZI violating (blob) rescattering;

\[ B^0 \rightarrow J/\psi D^{(*)0} \] and \[ \bar{B} \rightarrow J/\psi D\pi^- \] from \[ |b\bar{d}c\bar{c}\rangle \] Fock component via
(c) exchange and
(d) spectator diagrams

(e) \( bc \) annihilation in \[ |b\bar{d}c\bar{c}\rangle \] Fock component:

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

**Strength?** Larger Fraction than in Light Hadrons!

- Analysis of EMC Data (Harris, Smith and Vogt 1996) $\Rightarrow$ IC $\sim$ 0.86%!
- Since $|uudc\bar{c}\rangle$ Fock component of $p$ $\sim$ fluctuation on “borrowed $E$”
  $\Rightarrow$ IC $|b \bar{q} c \bar{c}\rangle$ LARGER in B Meson
  $\propto \left(\frac{m_p^2}{M_{uudc\bar{c}}}\right)^2$ $\times \left(\frac{m_B^2}{M_{bq\bar{c}c\bar{c}}}\right)^2$

Better Bank to borrow from.

In any case, Heavy Mesons Smaller, so, Higher Frequency Components.
Hint from CLEO & Belle Inclusive $J/\psi$ Data

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.

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

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

Note $p_{J/\psi}$ Spectrum Peak $\sim 1.5$ GeV. Rather Soft.

Suggest Possibility of $B_c \to J/\psi J/\psi \pi$.

Same Vertex

Smoking Gun Evidence (Finally) for $1C$, at $B$-Factories?

Amusing!

New Physics! As New Tricks from Old
New Discoveries/Phenomena

Be Prepared for