$e^+e^- \rightarrow B\bar{B}$ in soliton models

- Frascati data:
  $$\sigma(e^+e^- \rightarrow p\bar{p})/\sigma(e^+e^- \rightarrow n\bar{n}) \approx 1 \text{ at threshold}$$

  quite puzzling, as in Feynman diagram description

  $$e^+e^- \xrightarrow{\text{QED}} \gamma^* \xrightarrow{\text{QED}} q\bar{q} \xrightarrow{\text{QCD}} B\bar{B}$$

  QCD is flavor-blind, so expect

  $x$-section $\propto$ to sum of (quark charges)$^2$:

  $$\sigma(e^+e^- \rightarrow B\bar{B}) \propto \sum_e q_e^2$$

- Similar puzzle from CLEO (and L3) data on

  $$\gamma\gamma \rightarrow B\bar{B} \quad B = \Lambda, p$$

  close to threshold

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\[ \gamma \gamma \rightarrow p \bar{p} \quad \text{vs.} \quad \gamma \gamma \rightarrow \Lambda \bar{\Lambda} \]

similar to \( n \bar{n} \) vs. \( p \bar{p} \) in \( e^+e^- \):
equal cross-sections at threshold

CLEO data for \( \sigma_{\gamma \gamma \rightarrow \Lambda \bar{\Lambda}}(W) \), \( \sigma_{\gamma \gamma \rightarrow p \bar{p}}(W) \) for \( |\cos \theta^*| < 0.6 \).

Vertical error-bars include systematic uncertainties.
Horizontal markings indicate bin width.
S-model: scalar quark-diquark model;
V-model: vector quark-diquark model;


\[ \Rightarrow \] naive Feynman diagram description
clearly wrong at threshold
alternative description in soliton picture:

baryons $\leftrightarrow$ chiral solitons (Skyrmions)

helpful to thing about the reverse processes:

$$B\bar{B} \longrightarrow e^+e^-$$

and

$$B\bar{B} \longrightarrow \gamma\gamma$$

a two-stage process:

1. $B\bar{B} \longrightarrow$ pions: strong interaction, flavor-blind
   soliton-antisoliton annihilation – very fast

   memory of initial state lost - $p\bar{p}$ vs. $n\bar{n}$, etc.

2. pions $\longrightarrow e^+e^-$

   pions $\longrightarrow \gamma\gamma$

   etc.

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a more detailed description of $B \bar{B} \rightarrow \text{pions} \rightarrow e^+ e^-$

$N \bar{N}$ annihilation $\Leftrightarrow$ Skyrmion-anti-Skyrmion ($S \bar{S}$) annihilation. immediately when $S$ and $\bar{S}$ touch, a classical pion wave emerges as a coherent burst, taking away energy and baryon number as fast as causality permits.

after the fast annihilation, a spherically symmetric “blob” of pionic matter is formed, with size $\sim 1 \text{ fm}$, $N_{\text{baryon}} = 0$, and $E_{\text{tot}} = 2M_N$

further evolution of the system & branching rates for various channels are completely determined by the “blob” parameters; in particular, no memory whether initial state was $p\bar{p}$ or $n\bar{n}$

a crude model: sum over intermediate states with $n$ pions, where $n$ goes over all allowed values,

$$\sigma(p\bar{p} \rightarrow e^+ e^-) \sim \sum_n \sigma(p\bar{p} \rightarrow n\pi) \times \sigma(n\pi \rightarrow e^+ e^-)$$

and similarly for $n\bar{n} \rightarrow e^+ e^-$. 

$$\Rightarrow \sigma(e^+ e^- \rightarrow p\bar{p}) = \sigma(e^+ e^- \rightarrow n\bar{n})$$

a better model: use amplitudes, $\Sigma$ over all intermediate states

$$\Rightarrow$$ Novosibirsk precision low-$E$ data for $e^+ e^- \rightarrow \text{hadrons}$

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$e^+e^- \text{ Annihilation into Hadrons}$