Unquenching the Quark Model.

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Many versions of CQMs have been developed

(KI, CI, GBE, U(7), hCQM,Bonn, etc.)

non relativistic and relativistic

S

CQMs:

Good description of the spectrum

Predictions of many quantities:

- photocouplings
- helicity amplitudes
- elastic form factors
- structure functions

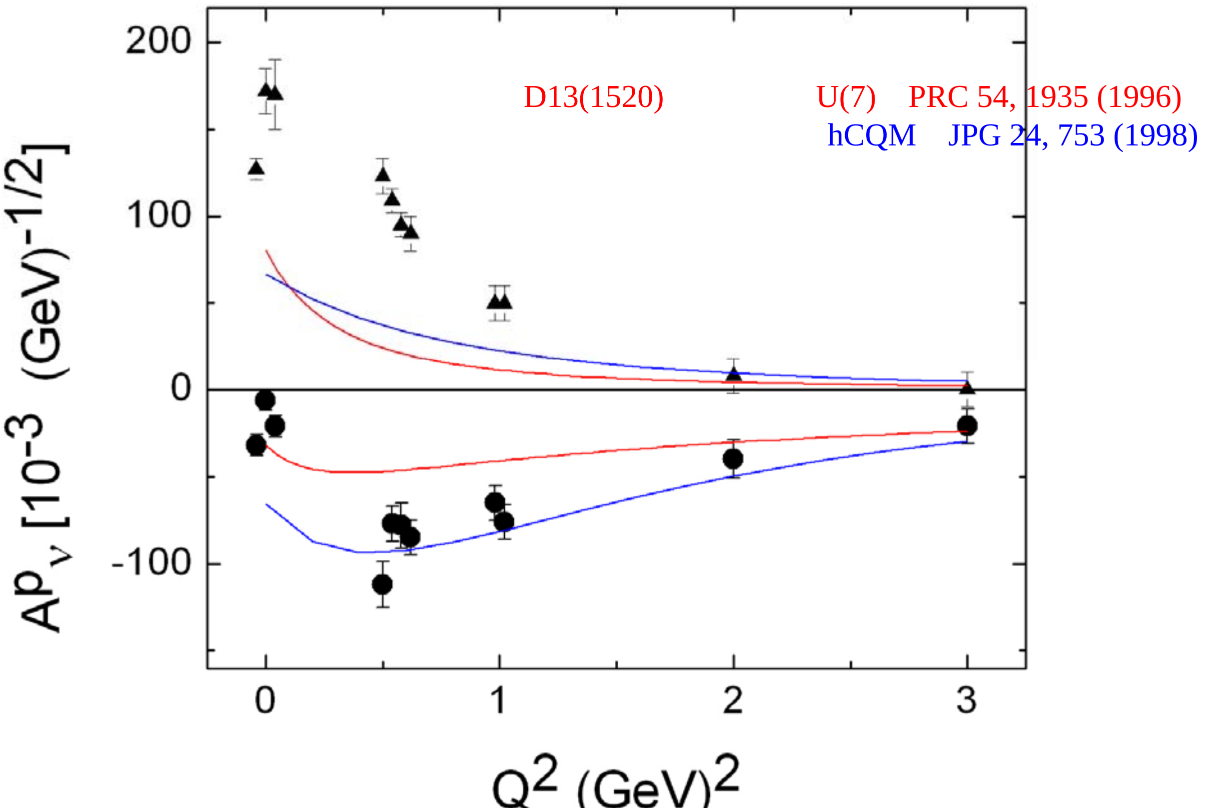
Based on the effective degrees of freedom of 3 constituent quarks

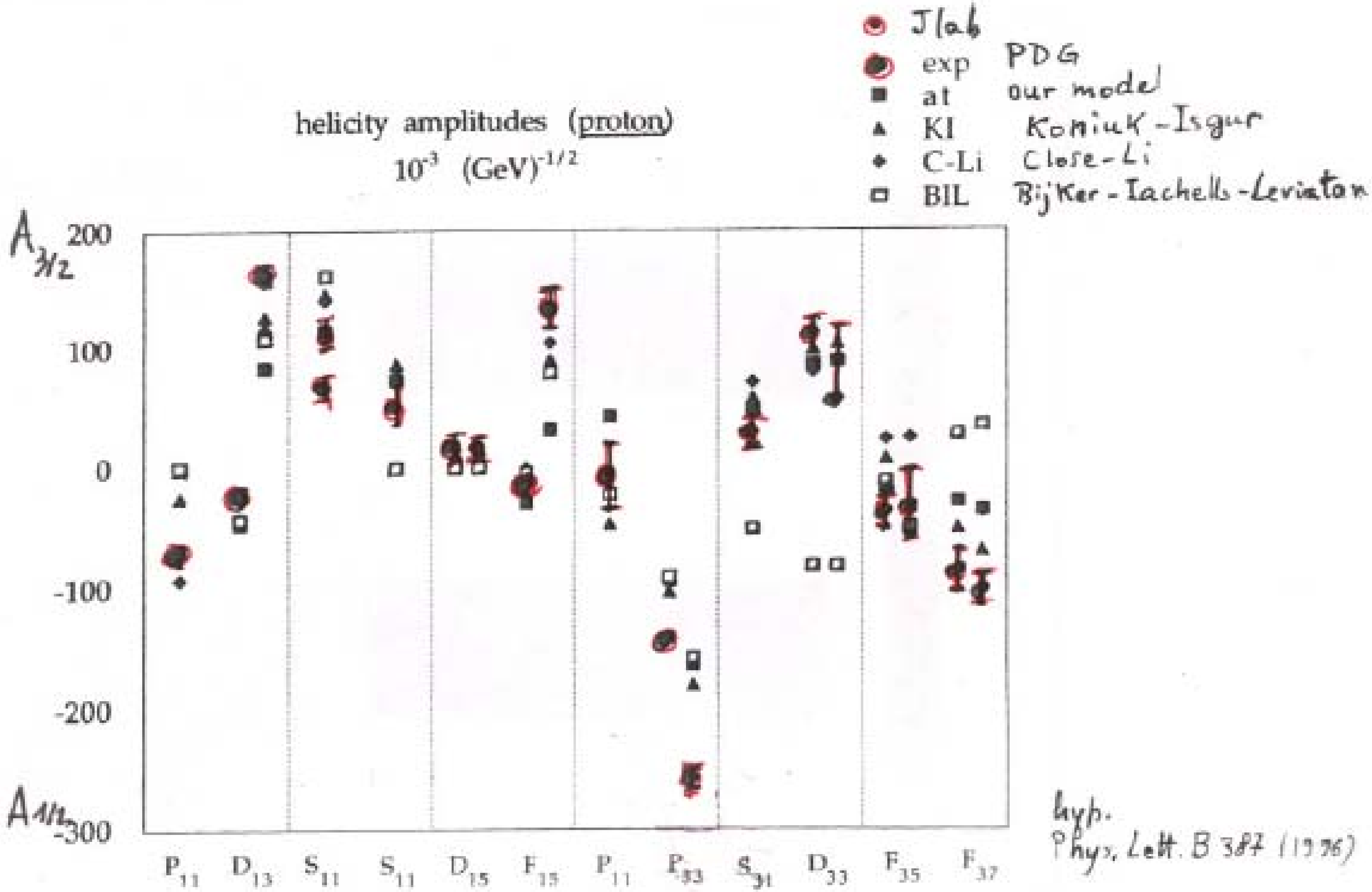
There are Open Problems

- Missing resonances
- Low Q^2 behavior of helicity amplitudes
- etc. …

Is it a degrees of freedom problem?

$q\bar{q}$ corrections ?





Jlab
exp PDG
at our model
KI Koniuk-Isgur
C-Li Close-Li
BIL Bijker-Iachello-Leviatan
helicity amplitudes (proton)
10^-3 (GeV)^-1/2
A3/2
A1/2
200
100
0
-100
-200
-300
P11 D13 S11 S11 D15 F15 P11 P33 S31 D33 F35 F37
hyp.
Phys. Lett. B 387 (1996)

QM's problems ----> degrees of freedom

Key degrees of freedom---->$q\bar{q}$ pair

There are two possibilities:

phenomenological parametrizations

microscopic explicit constituent description

Problems

1) find a quark pair creation mechanism QCD inspired

2) implementation of this mechanism in such a way to do not destroy the good QMs results

Isgur's flux-tube-breaking model for mesons

In the flux tube model Isgur has shown that a "miraculous" set of cancellations between apparently uncorrelated sets of mesons occurs in such a way that

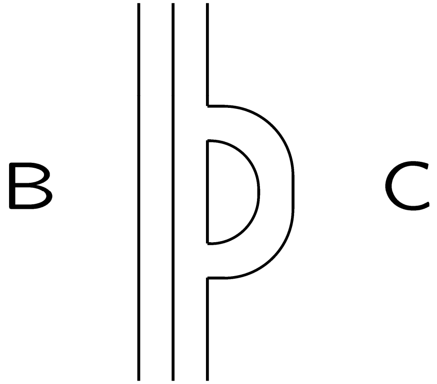
-the OZI hierarchy is preserved

-there is near immunity of the long range potential

it is necessary a to sum over very large towers of intermediate states to see that the spectrum is only weekly perturbed
great shift only from non adiabatic effects, as the result of the coupling of a resonance to a very nearby threshold for decays into other two.

→ **quark potential model as adiabatic limit**

Unquenched Quark Model



Strange quark-antiquark pairs in the proton with h.o. wave functions

Geiger & Isgur, PRD 55, 299 (1997)

- Pair-creation operator with $^3P_0$ quantum numbers of vacuum and geometry of flux-tube breaking model
- Sum over a large tower of intermediate states to preserve the phenomenological success of CQM's

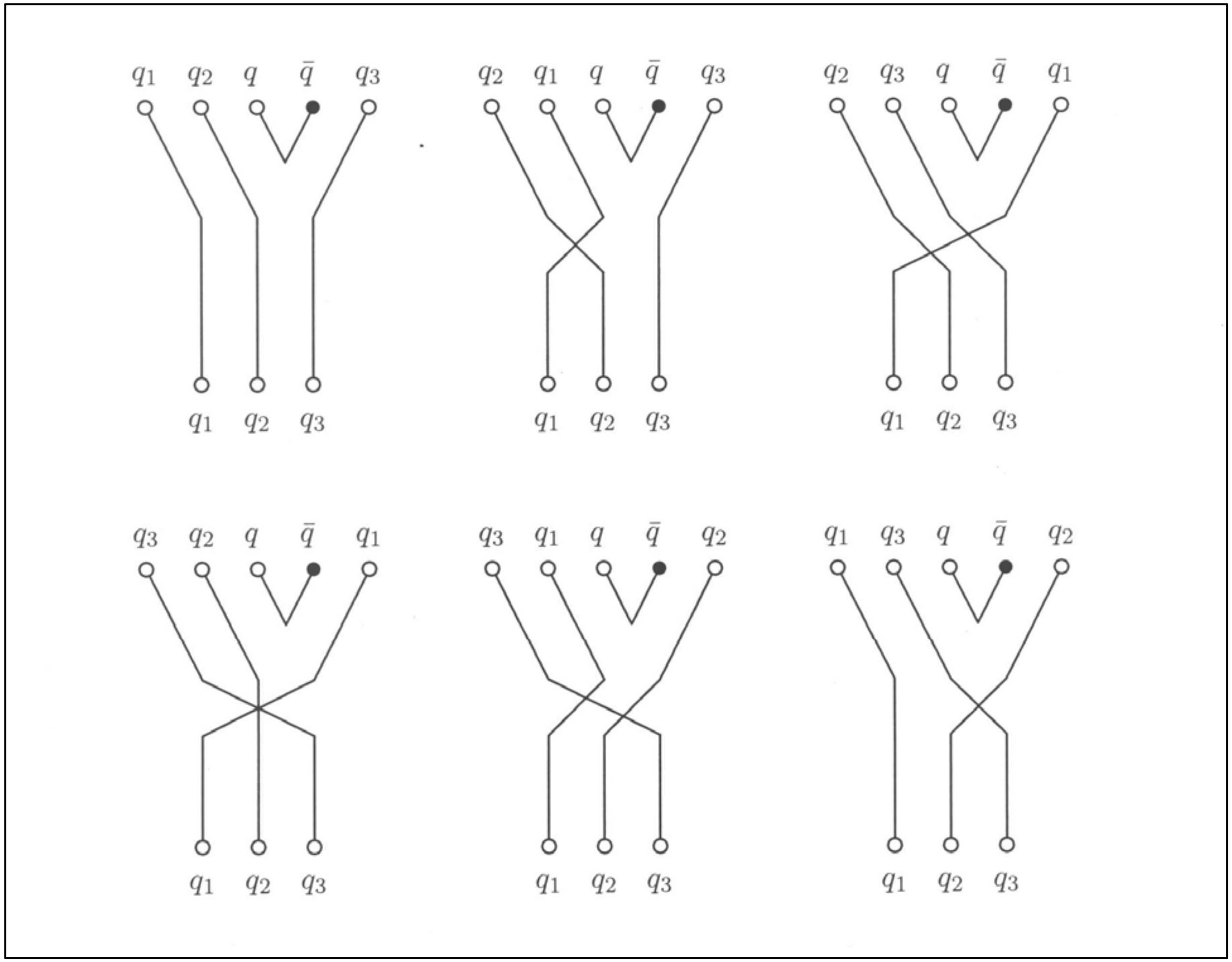
The creation mechanism is at the quark level -> (b)

Σ over all the towers of intermediate states

Pair creation model applied by Isgur to the strangeness content of the proton, or $O_s = \Delta S$, R_s^2, μ_s

$$|p\rangle \rightarrow |p\rangle + \sum_{Y^* K^* \ell S} \int q^2 dq \; |Y^* K^* q \ell S\rangle \frac{\langle Y^* K^* q \ell S | h_{s\bar{s}} | p\rangle}{M_p - E_{Y^*} - E_{K^*}} ,$$

$$\langle O_s \rangle = \sum_{\substack{Y^* K^* \ell S \\ Y^{*\prime} K^{*\prime} \ell' S'}} \int q^2 dq \; q'^2 dq' \frac{\left\langle p | h_{s\bar{s}} | Y^{*\prime} K^{*\prime} q' \ell' S' \right\rangle}{M_p - E_{Y^{*\prime}} - E_{K^{*\prime}}} \times \left\langle Y^{*\prime} K^{*\prime} q' \ell' S' | O_s | Y^* K^* q \ell S \right\rangle \frac{\langle Y^* K^* q \ell S | h_{s\bar{s}} | p\rangle}{M_p - E_{Y^*} - E_{K^*}} .$$



q_1 q_2 q $\bar{q}$ q_3
q_1 q_2 q_3
q_2 q_1 q $\bar{q}$ q_3
q_1 q_2 q_3
q_2 q_3 q $\bar{q}$ q_1
q_1 q_2 q_3
q_3 q_2 q $\bar{q}$ q_1
q_1 q_2 q_3
q_3 q_1 q $\bar{q}$ q_2
q_1 q_2 q_3
q_1 q_3 q $\bar{q}$ q_2
q_1 q_2 q_3

$$\langle O_s \rangle = \sum_{\substack{Y^* K^* \ell S \\ Y^{*\prime} K^{*\prime} \ell' S'}} \int q^2 dq\, q'^2 dq' \frac{\left\langle p \,|h_{s\bar{s}}|\, Y^{*\prime} K^{*\prime} q' \ell' S' \right\rangle}{M_p - E_{Y^{*\prime}} - E_{K^{*\prime}}}$$

$$\times \left\langle Y^{*\prime} K^{*\prime} q' \ell' S' \,|O_s|\, Y^* K^* q \ell S \right\rangle \frac{\langle Y^* K^* q \ell S \,|h_{s\bar{s}}|\, p \rangle}{M_p - E_{Y^*} - E_{K^*}} .$$

Closure limit ----->

$$\langle O_s \rangle \propto \langle p \,|h_{s\bar{s}} O_s h_{s\bar{s}}|\, p \rangle \propto \langle 0 \,|h_{s\bar{s}} O_s h_{s\bar{s}}|\, 0 \rangle ,$$

Good stringent test for the program. The corrections due to qq-pairs are zero in the closure limit. The sums over towers of states are constrained by the closure limit in such a way that very different meson and baryon states compensate.

It would be desirable to devise tests of the mechanisms underlying the delicate cancellations which conspire to hide the effects of the sea in the picture presented here. It also seems very worthwhile to extend this calculation to $u\bar{u}$ and $d\bar{d}$ loops. Such an extension could reveal the origin of the observed violations [38] of the Gottfried sum rule [39] and also complete our understanding of the origin of the spin crisis. From our previous calculations [4], the effects of "un-

Geiger & Isgur, PRD 55, 299 (1997)

Extensions

- To any initial baryon or baryon resonance
- To any flavor of the quark-antiquark pair
- To any model of baryons and mesons

Santopinto & Bijker, nucl-th/0701227
Bijker & Santopinto, nucl-th/0703053

Problems for the baryons---->

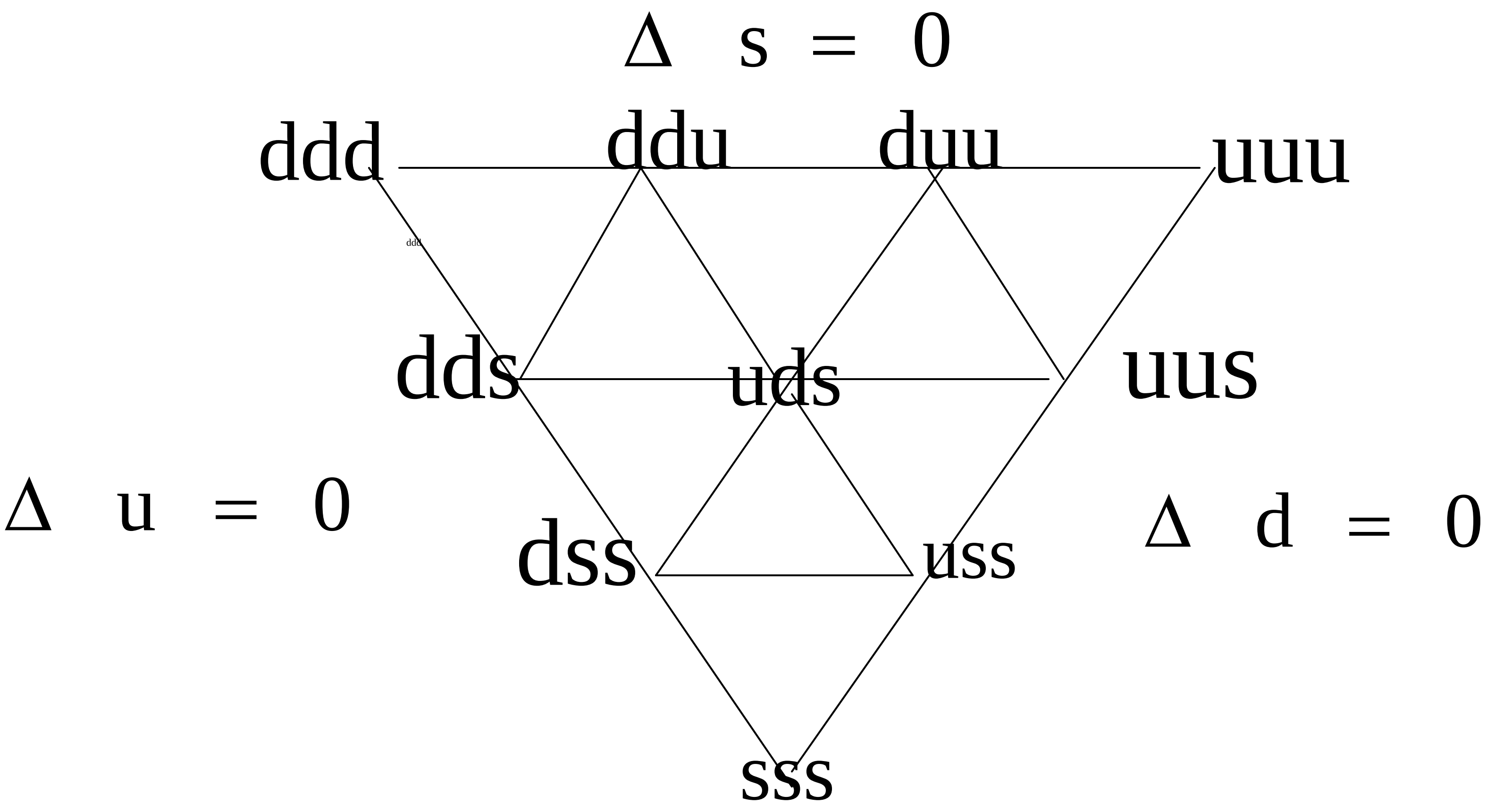
- big **towers of states** authomatically generated by means of group theoretical methods

- problems linked with **permutational symmetry(many different diagrams)-**> solved with group theoretical methods

$$|\,\psi_A\rangle = \mathcal{N}\left\{|\,A\rangle + \sum_{qBClJ}\int d\vec{k}\;|\,BC\vec{k}\,lJ\rangle\,\frac{\langle BC\vec{k}\,lJ\,|\,h^{\dagger}_{q\bar{q}}\,|\,A\rangle}{M_A - E_B - E_C}\right\}$$

$$\begin{aligned}
\mathcal{O} &= \langle\psi_A\,|\,\hat{\mathcal{O}}\,|\,\psi_A\rangle = \mathcal{O}_{\textsf{valence}} + \mathcal{O}_{\textsf{sea}}\\
\mathcal{O}_{\textsf{valence}} &= \mathcal{N}^2\langle A\,|\,\hat{\mathcal{O}}\,|\,A\rangle\\
\mathcal{O}_{\textsf{sea}} &= \mathcal{N}^2\sum_{qBClJ}\int d\vec{k}\sum_{q'B'C'l'J'}\int d\vec{k}'\,\frac{\langle A\,|\,h_{q'\bar{q}'}\,|\,B'C'\vec{k}'\,l'J'\rangle}{M_A - E_{B'} - E_{C'}}\\
&\qquad \langle B'C'\vec{k}'\,l'J'\,|\,\mathcal{O}\,|\,BC\vec{k}\,lJ\rangle\,\frac{\langle BC\vec{k}\,lJ\,|\,h^{\dagger}_{q\bar{q}}\,|\,A\rangle}{M_A - E_B - E_C}
\end{aligned}$$

The closure-limit and the symmetries give strong constraints



Preliminary results

Preliminary

$\Delta u = 1$	$\Delta u_{NRCQM} = 4/3$	$\Delta u_{RCQM} = 1.01$
$\Delta d = -$	$\Delta u_{NRCQM} = -1/3$	$\Delta u_{RCQM} = -0.25$
$\Delta s = -$ … (13)	$\Delta u_{NRCQM} = 0$	$\Delta u_{RCQM} = 0.00$

…ES collaboration
hep-ph/0609039

In the closure limit

$\Delta u : \Delta d : \Delta s = 4 : -1 : 0$

Conclusions

- Unquenched quark model:we have extended it to any flavor
- First results very promising
- Future:applications to many observables.