THE HIGGS BOSON AND QUARK COMPOSITENESS

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OUTLINE OF THE TALK

I) MOTIVATION;

II) QUARK COMPOSITENESS MODEL;

III) PROPOSED STRUCTURE FOR THE PROTON;

IV) PROPOSED STRUCTURE FOR THE NEUTRON;

V) IMPORTANT POSTULATE ON SPIN;

VI) BACK TO THE CORE CONUNDRUM;

VII) CURRENT VIEWS OF THE NUCLEON STRUCTURE;

VIII) THE CHARGE FLAW;

IX) INCOMPATIBILITY WITH ASYMPTOTIC FREEDOM;

X) THE FINAL BLOW OF G. MILLER;

XI) A NEW SU(2);

XII) CONNECTION TO THE WEAK DECAYS OF HADRONS;

XIII) THE SPIN OF THE HIGGS-LIKE BOSONS;

XIV) GENERATION OF QUARK MASSES;

XV) THE HIGGS-LIKE BOSONS QUANTUM NUMBERS;

XVI) PREDICTIONS OF INTERACTIONS;
MOTIVATION

I) A) THE ELECTRIC CHARGE DISTRIBUTIONS IN THE NUCLEONS

By Robert Hofstadter, Stanford University (Elastic Scattering experiments with electrons)
Robert Hofstadter shared the Noble Prize of 1961 with Rudolph Mössbauer.

1. Both nucleons have about the same inner core;
2. The inner core has charge +1/2e;
3. Peak of the inner core around 0.2 fm
B) In the SLAC report *The Discovery of Quarks*, Michael Riordan states on page 6, on the results concerning the invariant momentum transfer to the proton:

“A way to interpret this unexpected behavior was that the electrons were hitting some kind of hard core inside the target protons”

The electrons had energies of up to 20 GeV.

SLAC-PUB-5724, April 1992, on the DIS experiments conducted between 1967 and 1973 at Stanford by the famous collaboration MIT-SLAC that established the existence of quarks in the nucleon.

(Nobel Prize of 1990 for Friedman, Kendall and Taylor)
C) Many experimental groups have studied high-energy proton-proton elastic scattering at CERN and Fermilab and unanimously have reported:

**The proton has an inner hard core with a mean radius of about 0.2 fm.**

A detailed analysis and references for the data can be found in the papers:


II) QUARK COMPOSITENESS MODEL

Table 1. Electric charges of primons (preons, prequarks)

<table>
<thead>
<tr>
<th>Superflavor</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$</td>
<td>+$\frac{5}{6}$</td>
</tr>
<tr>
<td>$p_2$</td>
<td>$-\frac{1}{6}$</td>
</tr>
<tr>
<td>$p_3$</td>
<td>$-\frac{1}{6}$</td>
</tr>
<tr>
<td>$p_4$</td>
<td>$-\frac{1}{6}$</td>
</tr>
</tbody>
</table>

Table 2. Composition of quark flavors

<table>
<thead>
<tr>
<th></th>
<th>$p_1$</th>
<th>$p_2$</th>
<th>$p_3$</th>
<th>$p_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p_2$</td>
<td>$u$</td>
<td></td>
<td>$d$</td>
<td>$s$</td>
</tr>
<tr>
<td>$p_3$</td>
<td>$c$</td>
<td>$d$</td>
<td></td>
<td>$b$</td>
</tr>
<tr>
<td>$p_4$</td>
<td>$t$</td>
<td>$s$</td>
<td>$b$</td>
<td></td>
</tr>
</tbody>
</table>
III) PROPOSED STRUCTURE FOR THE PROTON
(agreeing with Hofstadter results)

Charge of the inner core: \[ \frac{5}{6}e + (-\frac{1}{6})e + (-\frac{1}{6})e = +1/2e \]
Charge of the outer layer: \[ \frac{5}{6}e + (-\frac{1}{6})e + (-\frac{1}{6})e = +1/2e \]
IV) PROPOSED STRUCTURE FOR THE NEUTRON
(agreeing with Hofstadter results)

Charge of the inner core: \(+\frac{5}{6}e + (-\frac{1}{6})e + (-\frac{1}{6})e = +\frac{1}{2}e\)

Charge of the outer layer: \(-\frac{1}{6}e + (-\frac{1}{6})e + (-\frac{1}{6})e = -\frac{1}{2}e\)

Find details of the model at
V) IMPORTANT POSTULATE ON SPIN

In order to obtain $S_z = \pm 1/2 \hbar$ for quarks we should have
$S_z = \pm 1/4 \hbar$ for primons. Thus, we postulate that primons are fermions ($S = 1/2 \hbar$) but with $S_z = \pm 1/4 \hbar$. This solves the so-called Proton Spin Puzzle.

Hard core and outer layer have, each

$$S_z = (\pm 1/4 \pm 1/4 \mp 1/4) \hbar = \pm 1/4 \hbar$$
VI) BACK TO THE CORE CONUNDRUM

The core has been seen by the TOTEM Collaboration at the energies of 7 TeV (LHC) and 8 TeV (LHC).

The TOTEM Collaboration, G. Antchev et al., EPL, vol 95, 41001, 2011; EPL, vol. 96, 21002, 2011 (results for 7 TeV)
PRL Vol. 111, 0120001, 2013 (results for 8 TeV)

In the summary of the last paper above it is said that the measurements at 7 TeV and 8 TeV “are both in good agreement with the extrapolation of the lower energy measurements”.

CERN Courier
Sep 23, 2011

TOTEM probes new depths in pp elastic scattering
Christine Sutton

This article analyzes the data at 7 TeV

“It clearly exhibits the global features that were first seen at the ISR.”
VII) CURRENT VIEWS OF THE NUCLEON STRUCTURE

3 valence quarks + pion cloud

or

3 valence quarks + cloud of $q\bar{q}$ pairs

(Valence quarks are almost massless)

As I show below both models have an important FLAW
VIII) THE CHARGE FLAW

According to Hofstadter results both nucleons have a similar inner core with an electric charge of $+\frac{1}{2}e$ but both models above have an inner core with an electric charge of $+1e$.
IX) BESIDES THIS FLAW THERE IS INCOMPATIBILITY BETWEEN ASYMPTOTIC FREEDOM AND THE EXISTENCE OF A CORE OF VALENCE QUARKS BECAUSE:

CONTRARY TO WHAT WOULD BE EXPECTED THE SEVERAL SCATTERING EXPERIMENTS WITH ENERGIES FROM 188 MeV UP TO 8 TeV HAVE REVEALED THE SAME INNER HARD CORE.

DUE TO ASYMPTOTIC FREEDOM THE BINDING AMONG THE 3 QUARKS WOULD DIMINISH WITH INCREASING ENERGY. AT EXTREMELY HIGH ENERGIES, SUCH AS 7 AND 8 TeV THE INNER CORE WOULD GET BLURRED OR WOULD DISAPPEAR.
X) THE FINAL WORD

GERALD MILLER RESULTS

Prof. G. A. Miller's analysis of experimental data revealed that

THE NEUTRON HAS A NEGATIVE CHARGE OF - 1/3e INSIDE THE CENTRAL POSITIVE REGION, THAT IS, INSIDE THE HARD CORE.


Please, see also
Journey to the Center of the Neutron by
J. Arrington/Argonne
Phys. Rev. Focus, 26 September 2008

IF THE INNER CORE WERE COMPOSED OF 3 VALENCE QUARKS WE WOULD HAVE A NEGATIVE CHARGE EQUAL TO – 2/3e INSTEAD OF – 1/3e.

WHAT IS THE ORIGIN OF THE – 1/3e CHARGE?
THE SIMPLE ANSWER

Charge of the inner core: \( +\frac{5}{6}e + (-\frac{1}{6})e + (-\frac{1}{6})e = +\frac{1}{2}e \)

Negative charge of the inner core: \( -\frac{1}{6}e + (-\frac{1}{6})e = -\frac{1}{3}e \)

CONCLUSION ON THE STRUCTURE CONUNDRUM:

1) THE VALENCE QUARKS ARE, ACTUALLY, PREQUARKS (PRIMONS);
2) CONSTITUENT QUARKS ARE THE TRUE QUARKS.

XI) A NEW SU(2)

FOLLOWING THE FOOTSTEPS OF GELL-MANN AND USING THE MODIFIED GELL-MANN – NISHIJIMA FORMULAS

\[ Q = 2B + 1/2(P_1 + P_2 + P_3 + P_4) \]

AND

\[ Q = I_3 + 1/2(B + \Sigma_3) \]

WE OBTAIN THE TWO TABLES

<table>
<thead>
<tr>
<th></th>
<th>( I_3 )</th>
<th>( \Sigma_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_1 )</td>
<td>( +\frac{1}{4} )</td>
<td>1</td>
</tr>
<tr>
<td>( p_j ) (( j = 2,3,4 ))</td>
<td>( +\frac{1}{4} )</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>( I_3 )</th>
<th>( \Sigma_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( c,t )</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>( u )</td>
<td>( +\frac{1}{2} )</td>
<td>0</td>
</tr>
<tr>
<td>( d )</td>
<td>( -\frac{1}{2} )</td>
<td>0</td>
</tr>
<tr>
<td>( s,b )</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>
This last table is directly linked to the CKM matrix elements

XII) and to the weak decays of all hadrons

Two examples

1) Semileptonic decays of light baryons

<table>
<thead>
<tr>
<th>Decay</th>
<th>Cabibbo factor</th>
<th>$\Delta \Sigma_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n \to p$</td>
<td>$\cos \theta_c$</td>
<td>0</td>
</tr>
<tr>
<td>$\Sigma^+ \to \Lambda$</td>
<td>$\cos \theta_c$</td>
<td>0</td>
</tr>
<tr>
<td>$\Sigma^- \to \Lambda$</td>
<td>$\cos \theta_c$</td>
<td>0</td>
</tr>
<tr>
<td>$\Sigma^- \to \Sigma^0$</td>
<td>$\cos \theta_c$</td>
<td>0</td>
</tr>
<tr>
<td>$\Lambda \to p$</td>
<td>$\sin \theta_c$</td>
<td>+1</td>
</tr>
<tr>
<td>$\Sigma^- \to n$</td>
<td>$\sin \theta_c$</td>
<td>+1</td>
</tr>
<tr>
<td>$\Xi^- \to \Lambda$</td>
<td>$\sin \theta_c$</td>
<td>+1</td>
</tr>
<tr>
<td>$\Xi^- \to \Sigma^0$</td>
<td>$\sin \theta_c$</td>
<td>+1</td>
</tr>
<tr>
<td>$\Xi^0 \to \Sigma^+$</td>
<td>$\sin \theta_c$</td>
<td>+1</td>
</tr>
<tr>
<td>$\Xi^- \to \Xi^0$</td>
<td>$\cos \theta_c$</td>
<td>0</td>
</tr>
</tbody>
</table>
2) Nonleptonic decays of light baryons

All decays with branching ratios above 8.6% have $\Delta \Sigma_3 = +1$ and $|\Delta I| = 1/2$. All forbidden decays (by $\Delta S = 2$) have other values for $\Delta \Sigma_3$

| Decay   | Branching ratios | $\Delta \Sigma_3$ | $|\Delta I|$ |
|---------|------------------|-------------------|------------|
| $\Lambda \rightarrow p\pi^-$ | 63.9%            | +1                | 1/2        |
| $\Lambda \rightarrow n\pi^0$ | 35.8%            | +1                | 1/2        |
| $\Sigma^+ \rightarrow p\pi^0$ | 51.6%            | +1                | 1/2        |
| $\Sigma^+ \rightarrow n\pi^+$ | 48.3%            | +1                | 1/2        |
| $\Sigma^- \rightarrow n\pi^-$ | 99.9%            | +1                | 1/2        |
| $\Xi^0 \rightarrow \Lambda\pi^0$ | 99.5%            | +1                | 1/2        |
| $\Xi^- \rightarrow \Lambda\pi^-$ | 99.9%            | +1                | 1/2        |
| $\Omega \rightarrow \Xi^0\pi^0$ | 67.8%            | +1                | 1/2        |
| $\Omega \rightarrow \Xi^-\pi^0$ | 23.6%            | +1                | 1/2        |
| $\Omega \rightarrow \Lambda K^-$ | 8.6%             | +1                | 1/2        |
| $\Omega \rightarrow \Lambda\pi^-$ | $<2.9 \times 10^{-6}$ | +2                | +1        |
| $\Xi^0 \rightarrow p\pi^-$ | $<8 \times 10^{-6}$ | +2                | +1        |
| $\Xi^- \rightarrow n\pi^-$ | $<1.9 \times 10^{-5}$ | +2                | +1        |

For all the other weak decays access

M. E. de Souza, Weak decays of hadrons reveal compositeness of quarks, Scientia Plena, vol. 4 (6), 064801-1
XIII) The Spin of the Higgs-like Bosons

As each Higgs-like boson acts between two different primons, its spin has to be equal to zero.

XIV) Generation of Quark Masses

It is proposed that from the interaction between each pair of primons, mediated by each Higgs-like boson, each quark mass is formed. Taking into account the charges of primons we construct the following table:

**Generating quark masses**

<table>
<thead>
<tr>
<th>Quark</th>
<th>Mass (GeV)</th>
<th>Charge</th>
<th>Higgs-like boson</th>
</tr>
</thead>
<tbody>
<tr>
<td>$u(p,p_3)$</td>
<td>0.3</td>
<td>$+2/3$</td>
<td>$H^+, H^-$</td>
</tr>
<tr>
<td>$c(p,p_3)$</td>
<td>1.5</td>
<td>$+2/3$</td>
<td>$H^+, H^-$</td>
</tr>
<tr>
<td>$t(p,p_3)$</td>
<td>170</td>
<td>$+2/3$</td>
<td>$H^+, H^-$</td>
</tr>
<tr>
<td>$d(p_2,p_3)$</td>
<td>0.3</td>
<td>$-1/3$</td>
<td>$H^0$</td>
</tr>
<tr>
<td>$s(p_2,p_3)$</td>
<td>0.5</td>
<td>$-1/3$</td>
<td>$H^0$</td>
</tr>
<tr>
<td>$b(p_2,p_3)$</td>
<td>4.5</td>
<td>$-1/3$</td>
<td>$H^0$</td>
</tr>
</tbody>
</table>
XV) THE HIGGS-LIKE BOSONS QUANTUM NUMBERS

Taking into account the values of $\Sigma_3$ for primons and the composition of quarks in terms of primons we obtain the quantum numbers for the Higgs-like bosons, summarized on the table below.

<table>
<thead>
<tr>
<th>$\Sigma_3$</th>
<th>$H^0$</th>
<th>$H^+, H^-$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pm 1(s, b)$</td>
<td>$\pm 1(s, b)$</td>
<td>$\pm 2(u)$</td>
</tr>
<tr>
<td>$0(d)$</td>
<td>$0(d)$</td>
<td>$\pm 1(c, t)$</td>
</tr>
</tbody>
</table>

Therefore, $H^0$ should be a triplet: $H^0(+1), H^0(0), H^0(-1)$

and $H^+$ and $H^-$ should be a doublet, each.

In terms of mass we should have a doublet for $H^0$ and two doublets for each charged Higgs-like boson.

For more details, please take a look at
XVI) PREDICTIONS FOR INTERACTIONS

SUPPRESSED INTERACTIONS FOR $H^0$

From the values of $\Sigma_3$ for primons we obtain exactly three suppressed interactions involving $H^0$ which are the interactions

\[ u \leftrightarrow u, \ c \leftrightarrow c \ \text{and} \ t \leftrightarrow t. \]

This is an important prediction that can be experimentally tested.

FAVORABLE INTERACTIONS FOR $H^0(+1), H^0(-1)$ (INVOLVING HEAVY QUARKS)

\[ t \leftrightarrow t, \ b \leftrightarrow t \]

Please, see details of all interactions in the paper

M. E. de Souza, The Higgs-like Bosons Couplings to Quarks, Journal of Nuclear and Particle Physics, 2013, 3(5); 140-144.
ILLUSTRATION OF THE BIG CONFUSION WITH RESPECT TO BJORKEN SCALING AND VALENCE QUARKS, CONSTITUENT QUARKS AND PREQUARKS

ESTIMATION OF THE COUPLING CONSTANT FOR $u$ AND $d$ QUARKS

Using a Yukawa potential

$$0.3 GeV \sim G \frac{e^{-\mu r}}{r} \quad \text{with} \quad \mu \sim \frac{1}{125 GeV} \sim 100 \text{fm}^{-1} \quad \text{and}$$

$$r \sim 0.5 \text{fm}$$

from Hofstadter results, we obtain

$$G \sim 10^{21} GeV fm \quad \text{and} \quad g = \frac{G}{\hbar c} \sim 5 \times 10^{21}$$

This extremely large coupling constant explains why the inner core is so strongly bound.
SUMMARY

ROBERT HOFSTADTER FOUND PREQUARKS AT STANFORD MORE THAN 50 YEARS AGO

AND MANY EXPERIMENTS HAVE SINCE THEN SEEN DIFFERENT EFFECTS RELATED TO QUARK COMPOSITENESS
BE CAREFUL, SOME VERY IMPORTANT PEOPLE SAID UNWISE WORDS SUCH AS

Niels Bohr

This most eminent scientist was not immune to poor judgment:

- outspoken critic on Einstein’s light quantum;

- mercilessly denounced Schrödinger’s equation;
- discouraged Dirac to work on the relativistic electron theory;

- opposed Pauli’s introduction of the neutrino;

- ridiculed Yukawa’s theory of the meson;

- criticized Feymann’s approach to quantum electrodynamics