QCD and Standard Model

QCD = "Quantum Chromodynamics"
= quantum theory of nucleons

A neutron is not a proton and electron stuck together.

Gell-Mann 1961
QCD: protons and neutrons composed of "quarks"

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Mass</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>u</td>
<td>2.4 MeV</td>
<td>+2/3</td>
</tr>
<tr>
<td>d</td>
<td>4.8 MeV</td>
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- anti-matter

neutron = udd net charge = 0 \Rightarrow anti-neutron \bar{u}\bar{d}\bar{d} = 0
proton = uud net charge = +1 \Rightarrow anti-proton \bar{u}\bar{d}\bar{d} = -1

results in

\Rightarrow \text{beta decay} \Rightarrow \text{conversion of a quark to a quark}

\Rightarrow \text{e- Rule} - no free particle can have fractional charge

Many other (unstable) particles result from quark combs

Note: mass of quarks \ll mass of nucleon:

-proton \ u+u+d = 9.6 MeV
-extra mass \ (9.383 - 9.6) MeV = 928.7 MeV from field energy

-neutron \ u+d+d = 12.0 MeV
-extra mass \ (9.396 - 12.0) MeV = 927.6 MeV from field energy

\Rightarrow \text{Standard Model:}

World composed of combinations of small number of particles and fields
forces mediated by fields