CONSTITUENT MODELS AND THE QCD MASS SPLITTING

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The particle physics has been lately faced with the proliferation of flavors (several generations of quarks and leptons). To cope with this problem, a number of constituent models has been put forward recently. Both quarks and leptons are now composite objects made up of smaller subunits which are bound together by a very strong force.

The fundamental gauge interactions of the haplon model are based on the $U(1)_{em} \otimes SU(3)_c \otimes SU(4)_{hc}$ symmetry. Haplons are bound together by a confining hypercolor force $SU(4)_{hc}$ which becomes strong at a scale $\Lambda_{hc} \approx 1000$ GeV. This scale is of the order of the inverse size of the quarks and leptons.

There are two spin 1/2 haplons α and β, and two spin 0 haplons x and y. Their $U(1)_{em} \otimes SU(3)_c \otimes SU(4)_{hc}$ representations are: $\alpha \sim (-1/2, 3, 4)$, $\beta \sim (1/2, 3, 4)$, $x \sim (-1/6, 3, \bar{4})$ and $y \sim (1/2, \bar{3}, \bar{4})$. The simplest hypercolor singlet states of fermions are identified with the quarks and leptons of the first generation (the lower index denotes the color representation): $u=(\bar{\alpha}\,\bar{x})_3$, $d=(\bar{\beta}\,\bar{x})_3$, $\nu_e=(\bar{\alpha}\,\bar{y})_1$ and $e=(\bar{\beta}\,\bar{y})_1$. The simplest color exotic objects have the same haplon structure, but are color $\bar{6}$ and 8 in the quark and lepton sector respectivly. In the absence of QCD interactions $m(u^*)=m(u), \ldots, m(e^*)=m(e)$. We assume that the kernel of the Bethe-Salpeter equation is dominated by the one gluon exchange diagram and find the QCD mass contribution $m_{QCD}=\alpha_s \Lambda_{hc} V$, where for the two haplon states $V=C_2(2h)-2C_2(h)$ and C_2 is the corresponding $SU(3)_c$ Casimir operators. For the 1, 3, $\bar{6}$, and 8 color states we find respectively for the V value 8/3, 4/3, -2/3 and -1/3. Thus, e.g. $m(e^*)-m(e)=3\alpha_s \Lambda_{hc}$, $m(u^*)-m(u)=2\alpha_s \Lambda_{hc}$, where $\alpha_s \Lambda_{hc} \approx 50$ GeV.

H. Fritzsch and G. Mandelbaum, Phys. Lett. 102B(1981)319.