# Constraints on effective constituent quark masses from phenomenology

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From the assumption of a two-particle Hilbert space for mesons and from rather general properties of the effective quark-quark potential we constrain considerably the choice of effective constituent quark masses.

## 1 Nonrelativistic models

We consider the following form of the Hamiltonian for the quark-antiquark system

$$H = \frac{p^2}{2\mu} + V_0(r) + \boldsymbol{\sigma}_1 \cdot \boldsymbol{\sigma}_2 V_s(m_1, m_2; r),$$

where $\mu$ is the reduced mass of the system and $m_1$ and $m_2$ are the quark and antiquark masses.

We make rather general assumptions about the potential:

1. The central potential $V_0(r)$ is flavour independent
2. The central potential is monotonic function or $r$ and satisfies the conditions for a positive Laplacian and concavity
$$\frac{d}{dr} r^2 \frac{dV_0}{dr} > 0 \quad and \quad \frac{d^2 V_0}{dr^2} < 0.$$
3. The spin-spin potential $V_s$ satisfies condition that $\mu V_s$ decreases with total mass of both quarks $M = m_1 + m_2$
4. The spin-spin potential is monotonic function of $r$ and has positive Laplacian
$$\frac{d}{dr} r^2 \frac{dV_s}{dr} > 0$$

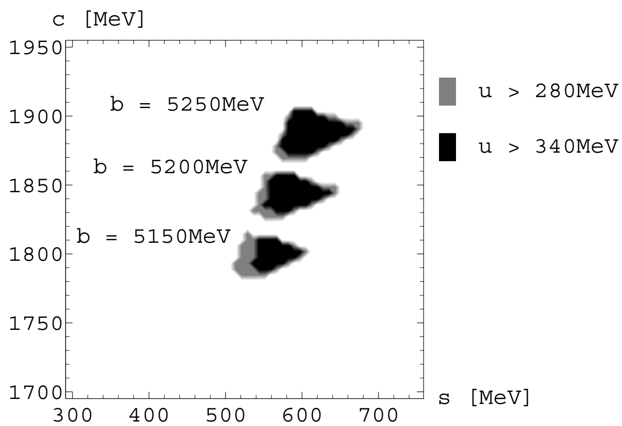


Figure 1: Allowed mass region for strange and charmed quarks for different choices of light and bottom quarks.

In the family of potentials which satisfy conditions 1. and 2. one can find the "QCD inspired" Coulomb-plus-linear potential and power law potential

$$V_0(r) = -\frac{\alpha}{r} + \beta r + U_0,$$
$$V_0(r) = A + Br^{\beta},$$

while conditions 3. and 4. are satisfied for example by

$$V_s(m_1, m_2; r) = \frac{\alpha}{m_1 m_2} \frac{e^{-r/r_0}}{r} \quad \alpha, r_0 > 0$$

From this assumptions one can obtain inequalities between quark masses and masses of ground state of pseudoscalar and vector mesons, which to some extent restrict masses of constituent quarks as shown in Fig(1).

# 2 Semirelativistic models

For heavy quark $Q$ - light (heavy) antiquark $q$ pseudoscalar mesons we use the semirelativistic model with Hamiltonian

$$H = \sqrt{p^2 + m_Q^2} + \sqrt{p^2 + m_q^2} + \frac{\boldsymbol{\sigma}_q \cdot \boldsymbol{\sigma}_Q}{m_q} F(m_Q) V_{ss} + V,$$

where we assumed that the expectation value of $F(m_Q)V_{ss}/m_q$ is monotonic decreasing function of $m_q$ and that both $V_{ss}$ and $V$ are flavour (mass) independent.

The Hamiltonian for all vector mesons in our model has the general form

$$H = \sqrt{p^2 + m_1^2} + \sqrt{p^2 + m_2^2} + V(m_1, m_2)$$

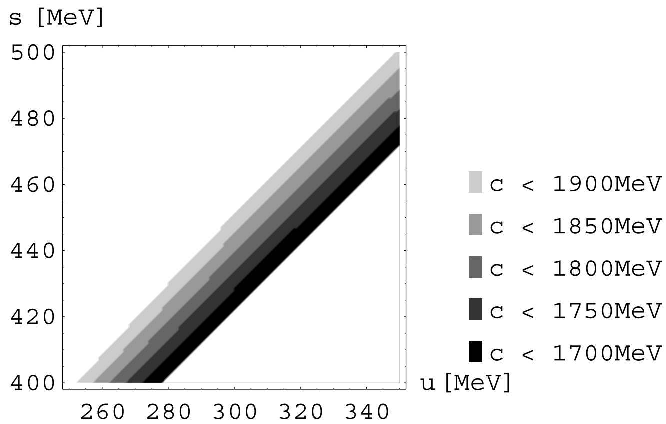


Figure 2: Allowed mass regions for light and strange quarks for five different choices for mass of charm quark.

where we demanded that the expectation value of $V(m_1, m_2)$ is a decreasing function of the quarks masses from where it follows that

$$
\begin{aligned}
E(K^*) - E(\rho) &< m_s - m_u \\
E(D^*) - E(K^*) &< m_c - m_s \\
E(B^*) - E(D^*) &< m_b - m_c
\end{aligned}
$$

Using this assumptions we again obtained inequalities between masses of quarks and mesons which allowed us to constrain masses of constituent quarks. In Fig(2) one can se that it is not possible to reproduce correctly the masses of ground state mesons with semirelativistic model if one takes mass of the charmed quark smaller then 1650MeV. Then the mass of bottom quark must be according to upper inequalities always larger then 4970MeV.