BARYON MASS SPECTRA WITH QCD–TYPE SCREENED POTENTIAL

V.V. Rubish

Department of Theoretical Physics,Uzhgorod State University,
32 Voloshyna Str.,UA-294000

The work is devoted to the description of baryon mass spectrum in the quasy–relativistic quark potential model. For cosidering 3–quark system advantageous is the use of hyperspherical functions. For obtaining the mass–seguence of Δ_{33} isobar the numerical computations were carryed out with the use of screened QCD–motivated potential, the use of which gives quite acceptable results even in the nonrelativistic approximation.

It is widely accepted that quark potential model is able to give a rather good description of heavy quark systems, though, the problem of application of such a model to the light quark systems,especially to baryon case is more complicated. On the other hand, the study of such systems is attractive for many reasons. Firstly, the experimental situation in this case is much more abundant. Secondly, there is no hope in near future to solve the relativistic three–body problem. Moreover, the baryon spectra are usualy treated separately from the meson ones and so the question arises how far the barions and mesons (both light and heavy ones) can be treated in the unified approach.

Usually the potential which is used nas the power–law form

$$V = -\frac{\alpha}{r} + Ar^{\gamma}, \qquad (1)$$

$\gamma = 1,\ 2,\ 2/3$. Of these potentials the most appropriate seems to be potential with $\gamma = 1$ called Cornell–potential. The attempt to compare all these potentials is given in [1] where the necessary references to previous works is also given.

On the other hand involving the virtual loop–diagram of fermions in lattice gauge calculation leads to colour screening effects–the potential does not rise at very large separation. Clearly, these colour screaning effects may reveal themselves in the highly–excited barion resonances. Meantime, a very promising QCD–motivated potential was proposed by Chikovani, Jenkovszky and Paccanoni (CJP) on the basis of the model of a non–perturbative gluon propagator. It was succesfully applied to the heavy meson spectroscopy [2] and it turns out that such a potential having the form

$$V = \frac{g^2}{6\pi\mu}(1 - e^{-\mu r}) - \frac{16\pi}{25}\frac{e^{-kr}}{\ln\left(b + \frac{1}{(\Lambda r)^2}\right)} \qquad (2)$$

contains color screening effects. None of the above mentioned power–law potentials posses the screening property. Previously, the colour screaning effects in baryon spectroscopy were studied in [3] using similar, but purely phenomenological potentials. In the present paper we shall study the baryon mass–spectra using the CJP potential.

To obtain the mass–spectrum of the three–quark problem one has to solve the eigenvalue problem, which in our model means solving the Schrödinger equation with the appropriate boundary conditions. To determine the wave function of relative motion $\varphi(\rho,\tau)$ we go over to the spherical coordinate system in the six–dimensional configuration spece, which is often referred to as hyperspherical coordinates.

As was disscused in [1] it turns out sufficient to restrict ourselves to K–zero approximation in which case the Schrödinger equation is reduced to a single radial equation:

$$\left[\frac{d^2}{dr^2} - \frac{K(K+!)}{r^2} - 2\mu(E - \langle\Phi_0|V(R,\alpha|\Phi_0\rangle\right]u(R) = 0 \qquad (3)$$

(Here $u(R)=R^{-5/2}\chi(R), K=\Lambda+3/2$).

The matrix elements $\langle\Phi_0|V(R,\alpha|\Phi_0\rangle$ according to [1], assume the form

$$W_n=\frac{16}{\pi}\int_0^{\pi/2}V(r_{ij})\cdot\sin^2\alpha\cdot\cos^2\alpha\cdot d\alpha. \quad (4)$$

The mass of three–quark system is calculated according to the relation

$$M=3m_q+E+V_0, \quad (5)$$

Here V_0 is additional parameter. Such parameters are present in QCD–motivated potentials and describe the energy level shift in QCD–vacuum. Besides V_0 can include in our model spin–dependent and relativistic corrections (like $p^2/8m^3$) and, thus, it can depend on quark mass. The discussion concerning the meaning of V_0 is given also in [4].

In what follows we have used the following values of the parameters. The masses of up and down quarks were taken to be as usually in quark models [1,4] $m_u=m_d=0.33GeV$ wich follows from magnetic momentum considerations. For CJP potential the parameters were choosen as: $g^2/6\pi=0.24GeV^2$, $\mu=0.054GeV^4$ $\Lambda=0.35GeV$, $k=0.75GeV^2$, $b=4$ [2]. While V_0 is chosen to be equal $V_0=1.367GeV$.

In the present paper, we have considered Δ_{33}–trajectories with the following quantum numbers $P=+1$, $J=3/2$, 7/2, 11/2,... and with signature σ = 1. The results of calculations together with experimental data are presented in table 1. The experimental data are taken from [5].

Table 1. Baryon count, Δ_{33}–trajectory (MeV)

N	L	$(3/2)^+$	$(7/2)^+$	$(11/2)^+$	$(15/2)^+$
0	M_{EXP}	1232±2	1950±10	2420±80	2950±70
	CJP	1233	1953	2479	2949
1	M_{EXP}	1920±80	2390±38		
	CJP	1813	2397		χ^2=1.35
2	M_{EXP}	—			
	CJP	2290			

As one can see from the table 1, the description of the existing data given by CJP potential is very good. So we can see that in addition to $q\bar{q}$ – systems [6] the screened QCD–type potential gives also the description of qqq–systems, i.e. baryons.

References

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СПЕКТР МАС БАРІОНІВ З ЕКРАНОВАНИМ КХД–МОТИВОВАНИМ ПОТЕНЦІАЛОМ

В.В. РУБІШ

Ужгородський державний університет, 294000, Ужгород, вул. Волошина, 32

Дана робота присвячена опису спектра мас баріонів в квазірелятивістській кварковій потенціальній моделі. При розгляді трикваркової системи велику перевагу дає використання метода гіперсферичних функцій. Для отримання спектра мас Δ_{33} ізобари були проведені чисельні розрахунки з використанням екранованого КХД–мотивованого потенціалу. Використання даного потенціалу дає непогані результати навіть в нерелятивістському наближенні.