EXOTIC BARYONS FROM THE CHIRAL QUARK SOLITON MODEL

D. BORISYUK, M. FABER[1], A. KOBUSHKIN

UDC 539.12

Bogolyubov Institute for Theoretical Physics, Nat. Acad. Sci. of Ukraine
(14b, Metrolohichna Str., Kyiv 03143, Ukraine),

[1]**Atominstitut der Österreichischen Universitäten, Technische Universität Wien**
(Wiedner Hauptstr. 8-10, A-1040 Vienna, Austria)

From the interpretation of the $\Theta^+(1540)$ and $\Xi_{3/2}(1862)$ baryons as an excitation of the "skyrmion liquid" with SU(3) flavour symmetry $\overline{10}$, we deduce a new series of baryons, Θ_1^{++}, Θ_1^+, and Θ_1^0 situated at the top of the 27-plet of SU(3) flavour, with hypercharge $Y = 2$, isospin $I = 1$, and spin $J = \frac{3}{2}$. The Θ_1 mass and width are estimated from the chiral quark soliton model. We demonstrate that the predicted mass, $m_{\Theta_1} = 1599$ MeV$/c^2$, and broad width are in qualitative conflict with experiment which shows no structure in the total K^+p cross section near $P_{\rm lab} = 585$ MeV$/c$. We also study properties of other exotic baryons from the 27- and 35-plets.

Introduction

Recently two exotic and narrow baryons, $\Theta^+(1540)$ and $\Xi^{--}_{3/2}(1862)$ which cannot be formed by three quarks were reported. Their simplest quark contents are $uudd\bar{s}$ and $ddss\bar{u}$, respectively. The $\Theta^+(1540)$ baryon was observed in few independent experiments [1–5]. Its hypercharge, $Y = 2$, follows from the strangeness conservation in electromagnetic and strong interactions. No evidence for a Θ^+ partner with electric charge $Q = 2$ was found, which excludes its isospin $I = 1$ [4, 6]. Despite some arguments that this state may be an isotensor [7, 8], we will assume later that the $\Theta^+(1540)$ baryon is an isosinglet.

Due to a finite detector resolution, the experiments [1–5] give an upper limit only for the $\Theta^+(1540)$ width, $\Gamma_{\Theta^+} < 9 \div 22$ MeV. Further restrictions (adopting the hypothesis that $\Theta^+(1540)$ is isoscalar) can be obtained from the K^+d total cross section, $\Gamma_{\Theta^+} < 6$ MeV, [9] and from PWA of K^+N scattering in the $I = 0$ channel, $\Gamma_{\Theta^+} < 1$ MeV, [10]. The later estimate agrees with the results of [11] and [12].

The $\Xi^{--}_{3/2}(1862)$ baryon with strangeness $S = -2$ was observed in the $\Xi^-\pi^-$ invariant mass spectrum in proton-proton scattering at the CERN SPS [13]. The width (including the experimental resolution) was reported to be about 18 MeV. The minimal possible isospin of this resonance is $I = \frac{3}{2}$. In the same experiment, another partner of this state, $\Xi^0_{3/2}$, was also observed as a peak in the $\Xi^-\pi^+$ invariant mass spectrum.

Before these experiments were done, there had been a lot of theoretical speculations about exotic baryons. Some of the speculations were based on pure quark model calculations [14–17], others — on the extended Skyrme soliton model for the SU(3) flavour multiplet $\mu = (0, 3)$ with dimension $N_\mu = \overline{10}$ (anti-decuplet) [18–23].

Three versions of the soliton model calculations [20, 22, 23] predicted the Θ^+ mass, $M^{\rm th}_{\Theta^+} = 1530$ MeV$/c^2$, in excellent agreement with experiment. Moreover, basing on the chiral quark soliton model, Diakonov, Petrov, and Polyakov [22] gave the important qualitative prediction that this state must be narrow, $\Gamma^{\rm th}_{\Theta^+} < 15$ MeV. The prediction for the $\Xi_{3/2}$ mass was not so successful ($M_{\Xi_{3/2}} = 2070$ MeV$/c^2$, [22] and 1785 MeV$/c^2$ in [24]), but, in principle, one can reproduce the masses of both exotic baryons by an appropriate choice of the model parameters [25]. Because these authors assume that both exotic baryons are members of the anti-decuplet, the baryon spin-parity is $J^P = \frac{1}{2}^+$. However, it must be mentioned that, in principle, these states can be also distributed between other penta-quark multiplets (27- and 35-plets) with spin different from $\frac{1}{2}$. Predictions for higher SU(3) flavour representations were discussed in [26, 27].

Contrary to the picture, where exotic baryons are considered as an excitation of a "skyrmion liquid" with appropriate SU(3) flavour symmetry, the approaches based on the constituent quark model were also elaborated [7, 8, 28–35]. In this pure multi-quark picture, $\Theta^+(1540)$ and $\Xi_{3/2}(1862)$ may have quantum numbers different from that predicted by the Skyrme model. The properties of the exotic baryons were also studied in the framework of QCD sum rules [36] and lattice QCD calculations [37].

The aim of the present paper is to study the properties (mass spectrum and widths) of penta-quark exotic states from the 27- and 35-plets in the framework of the chiral quark soliton model. We demonstrate that the present experimental information about the exotic baryons gives very strict restrictions on the parameters of the chiral quark soliton model. Using this restrictions, we make appropriate predictions for the 27- and 35-plets. We find that the (chiral quark soliton) model which works perfectly for the octet, decuplet, and anti-decuplet fails for higher-dimensional SU(3) flavour representations.

1. Exotic Baryons in the Chiral Quark Soliton Model

In our calculations, we use the Hamiltonian

$$\hat{H} = \hat{H}_0 + \Delta\hat{H}, \tag{1}$$

where $\hat{H}_0$ is the SU(3)-symmetric part and $\Delta\hat{H}$ is responsible for the splitting within SU(3) multiplets.

Using a hedgehog ansatz and assuming a rigid rotation in the SU(3) space [38, 39], the Skyrme Lagrangian yields the following Hamiltonian for the baryon representation $\mu = (p, q)$ of the SU(3) flavour group:

$$H_0 = M_0 + \frac{1}{6I_2}[p^2 + q^2 + pq + 3(p+q)] +$$

$$+ \left(\frac{1}{2I_1} - \frac{1}{2I_2}\right) J(J+1) - \frac{(N_c B)^2}{24 I_2}. \tag{2}$$

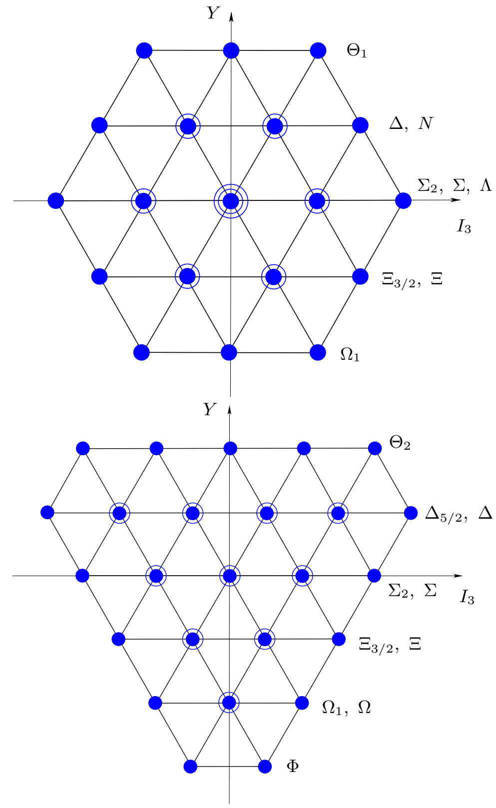
Here, J is the soliton spin, M_0 is the energy of the static soliton solution, I_1 and I_2 are the two moments of inertia, $N_c = 3$ is the number of colors, and $B = 1$ is the baryon number. All quantities M_0, I_1 and I_2 are functionals of the soliton profile.

Some authors (see, e.g., [40]) have expressed doubt about the validity of the rigid rotation aproximation for penta-quarks. Nevertheless, it was shown that such a doubt is ungrounded (see [41, Sect. 3]).

In the chiral quark soliton model, the Hamiltonian $\Delta\hat{H}$ is chosen phenomenologically [22] as

$$\Delta\hat{H} = \alpha D^{(8)}_{88}(R) + \beta Y + \frac{\gamma}{\sqrt{3}} \sum_{A=1}^{3} D^{(8)}_{8A}(R)\hat{J}_A. \tag{3}$$

Here, $R \in \mathrm{SU}(3)$, $D^{(8)}_{mn}(R) = \frac{1}{2}\mathrm{Tr}\left(R^\dagger \lambda_m R \lambda_n\right)$ are Wigner rotation matrices for the adjoint SU(3)



Structure of the 27- (upper figure) and 35-plets (bottom figure) of baryons in the $I_3 Y$ diagram. The number of circles shows the multiplicity

representation and Y is the hypercharge operator. The constants α, β and γ are related to the current quark masses, m_u, m_d, m_s, the nucleon sigma term, and four soliton moments of inertia.

Due to the Wess—Zumino term, the quantization rule selects only such soliton spins J which coincide with one of the allowed isospins I for hypercharge $Y = 1$ in the given SU(3) flavour multiplet [38, 39]. So the lightest irreducible SU(3) representations which can be associated with 3-quark and 4-quark–antiquark systems and appropriate spins J are

octet	$\mu = (1,1)$	$J = 1/2$,
decuplet	$\mu = (3,0)$	$J = 3/2$,
anti-decuplet	$\mu = (0,3)$	$J = 1/2$,
27-plet	$\mu = (2,2)$	$J = 1/2$ or $3/2$,

35-plet $\qquad \mu = (4,1) \qquad J = 3/2$ or $5/2$. (4)

The I_3Y diagram for the 27- and 35-plets of baryons is displayed in Figure.

The wave functions for baryons with hypercharge Y, isospin I, isospin 3-projection I_3, spin J, and its z-projection J_3 are

$$\Psi(R) = \langle R|\mu Y I I_3 J J_3\rangle =$$

$$= \sqrt{N_\mu}(-1)^{J_3-\frac{1}{2}} D^{\mu}_{YII_3;1J-J_3}(R), \tag{5}$$

where N_μ is the dimension of the representation μ. Using the first-order perturbation theory for Hamiltonian (1), we get the mass spectrum

$$M = M_0 + \frac{1}{6I_2}[p^2+q^2+pq+3(p+q)]+$$

$$+\left(\frac{1}{2I_1}-\frac{1}{2I_2}\right)J(J+1) - \frac{3}{8I_2} + \Delta M, \tag{6}$$

where

$$\Delta M = \langle \Delta\hat{H}\rangle =$$

$$= \langle \mu Y I I_3 J J_3|\Delta\hat{H}|\mu Y I I_3 J J_3\rangle. \tag{7}$$

These splittings are given in Table 1 together with the results of [22] for the anti-decuplet.

Exotic states are contained in the $\overline{10}$-, 27-, and 35-dimensional representations. For the further analysis, we introduce the following universal notations for the exotic states (they are different from the notations used in our previous paper [27]):

— for the states with the hypercharge $Y = 2$, we use Θ_I, where the suffix is its isospin; if $I = 0$, we use Θ without suffix;

— for $Y = 1$, we use the notation Δ_I;

— for $Y = 0$, we use Σ_I;

— for $Y = -1$, we use Ξ_I;

— for $Y = -2$, we use Ω_I;

— for $Y = -3$, we use Φ.

The anti-decuplet contains Θ and $\Xi_{3/2}$ exotic baryons which cannot be reduced to three-quark systems due to their Y and/or I values. From Figure, one learns that the 27-plet contains Θ_1, Σ_2, $\Xi_{3/2}$, and Ω_1 exotic states and the 35-plet contains Θ_2, $\Delta_{5/2}$, Σ_2, $\Xi_{3/2}$, Ω_1, and Φ exotic states. Other members of the $\overline{10}$-, 27-, and 35-multiplets are non-exotic with flavour quantum numbers of the octet and decuplet baryons. So these states exist as a mixture of penta-quark and three-quark systems.

2. Mass Spectrum of Exotic Baryons

The rotational energy is given by the second and third terms in (6). In general, it increases very strongly from the octet representation in (4) to the 35 representation. But there is an exception. It follows from numerical results that $I_1 > I_2$. This means that the term proportional to $J(J+1)$ in (6) becomes more negative for higher angular momenta. So for the 27-plet with $J = \frac{3}{2}$ and 35-plet with $J = \frac{5}{2}$, the increase of the rotational energy of the second term in (6) can be compensated by the increase of the negative contribution of the third term. For example, the estimates with typical parameters for the moments of inertia I_1 and I_2 show that the rotational energy for the 27-plet with $J = \frac{3}{2}$ increases by ≈ 100 MeV only, which, in principle, is of the order of the splitting within the SU(3) multiplet!

Table 1. Mass splitting in anti-decuplet with $J = \frac{1}{2}$, in 27-plets with $J = \frac{1}{2}$ and $\frac{3}{2}$ and in 35-plet with $J = \frac{5}{2}$

	Y	I	ΔM
		Anti-decuplet, $J = 1/2$	
Θ	2	0	$(1/4)\alpha + 2\beta - (1/8)\gamma$
N	1	1/2	$(1/8)\alpha + \beta - (1/16)\gamma$
Σ	0	1	0
$\Xi_{3/2}$	−1	3/2	$-(1/8)\alpha - \beta + (1/16)\gamma$
		27-plet, $J = 3/2$	
Θ_1	2	1	$(1/7)\alpha + 2\beta - (5/14)\gamma$
Δ	1	3/2	$(13/112)\alpha + \beta - (65/224)\gamma$
N	1	1/2	$(1/28)\alpha + \beta - (5/56)\gamma$
Σ_2	0	2	$(5/56)\alpha - (25/112)\gamma$
Σ	0	1	$-(1/56)\alpha + (5/112)\gamma$
Λ	0	0	$-(1/14)\alpha + (5/28)\gamma$
$\Xi_{3/2}$	−1	3/2	$-(1/14)\alpha - \beta + (5/28)\gamma$
Ξ	-1	1/2	$-(17/112)\alpha - \beta + (85/224)\gamma$
Ω_1	-2	1	$-(13/56)\alpha - 2\beta + (65/112)\gamma$
		27-plet, $J = 1/2$	
Θ_1	2	1	$(17/56)\alpha + 2\beta - (1/112)\gamma$
Δ	1	3/2	$(1/28)\alpha + \beta - (5/56)\gamma$
N	1	1/2	$(137/560)\alpha + \beta + (71/1120)\gamma$
Σ_2	0	2	$-(13/56)\alpha - (19/112)\gamma$
Σ	0	1	$(13/280)\alpha + (19/560)\gamma$
Λ	0	0	$(13/70)\alpha + (19/140)\gamma$
$\Xi_{3/2}$	−1	3/2	$-(17/112)\alpha - \beta + (1/224)\gamma$
Ξ	-1	1/2	$(2/35)\alpha - \beta + (11/70)\gamma$
Ω_1	−2	1	$-(1/14)\alpha - 2\beta + (5/28)\gamma$
		35-plet, $J = 5/2$	
Θ_2	2	2	$-(1/16)\alpha + 2\beta - (77/96)\gamma)$
$\Delta_{5/2}$	1	5/2	$(11/32)\alpha + \beta - (49/192)\gamma$
Δ	1	3/2	$-(1/8)\alpha + \beta - (7/16)\gamma$
Σ_2	0	2	$(3/16)\alpha + (7/96)\gamma$
Σ	0	1	$-(3/16)\alpha - (7/96)\gamma$
$\Xi_{3/2}$	−1	3/2	$(1/32)\alpha - \beta + (77/192)\gamma$
Ξ	−1	1/2	$-(1/4)\alpha - \beta + (7/24)\gamma$
Ω_1	−2	1	$-(1/8)\alpha - 2\beta - (35/48)\gamma$
Ω	−2	0	$-(5/16)\alpha - 2\beta + (21/32)\gamma$
Φ	−3	1/2	$-(9/32)\alpha - 3\beta + (203/192)\gamma$

In the further analysis, the momenta of inertia, I_1 and I_2, the energy of a static skyrmion, M_0, and the coefficients α, β, and γ are not calculated, but are regarded as phenomenological parameters. These parameters were estimated by the least square fit to the experimental masses of baryons from the octet and the decuplet and to those of Θ and $\Xi_{3/2}$ from $\overline{10}$. Finally, we get the following set of parameters:

$$1/I_1 = 154.5 \text{ MeV}, \quad 1/I_2 = 403.0 \text{ MeV},$$

$$\alpha = -602.7 \text{ MeV}, \quad \beta = -22.3 \text{ MeV},$$

$$\gamma = -154.5 \text{ MeV}, \quad M_0 = 790.3 \text{ MeV}. \tag{8}$$

The estimated masses are given in the left column of Table 2. One sees that the model predicts two $\Xi_{3/2}$ states with very small mass difference (less than 20 MeV/c^2) and different spins, $\frac{1}{2}$ and $\frac{3}{2}$. So, one cannot *a priori* exclude the possibility that the observed $\Xi_{3/2}(1862)$ can be a member of the 27-plet with $J = \frac{3}{2}$. We have also considered all possible billeting of Θ and $\Xi_{3/2}$ in different multiplets, but their widths can be consistent with experimental restrictions only if they belong to $\overline{10}$.

3. Decay Widths

In Introduction, we have already stressed that $\Theta^+(1540)$ is expected to be anomalously narrow. The smallness of its width was shown to be due the to the cancellation of the coupling constants of different orders in N_c [22,42].

Two-body decay widths of the baryons are calculated by sandwiching the baryon-baryon-meson coupling between the in- and out- baryon states. In terms of the collective rotation coordinates R, the coupling reads

$$-i\frac{3}{2m_B}\sum_{A=1}^{3}\left[G_0 D^{(8)}_{mA}(R) - G_1 \sum_{a,b=4}^{8} d_{Aab} D^{(8)}_{mb}(R) J_a - \right.$$

$$\left. -\sqrt{\frac{1}{3}} G_2 D^{(8)}_{m8}(R) J_A\right] p_A, \tag{9}$$

where d_{Aab} is the SU(3) symmetric tensor, the suffices are $a, b = 4, \ldots, 8$, $A = 1, 2, 3$ and $m = 1, \ldots, 8$ is the meson flavour index; $\vec{p}$ is the meson momentum in the resonance rest frame.

The coupling constants G_0 and $G_{1,2}$ have different orders in N_c

$$G_0 \sim N_c^{\frac{3}{2}}, \qquad G_{1,2} \sim N_c^{\frac{1}{2}}. \tag{10}$$

In [22], it was argued that

$$\frac{G_2}{G_0 + \frac{1}{2}G_1} \sim 0.01 \tag{11}$$

and thus one can neglect G_2 estimating baryon widths. After that, the nucleon-pion coupling constant reads [22]

$$g_{\pi NN} = \frac{7}{10}\left(G_0 + \frac{1}{2}G_1\right) = 13.6. \tag{12}$$

The ratio G_1/G_0 remains unknown and can be restricted only by model-dependent constraints. The authors of [22] obtained $\Theta_\Gamma^{\rm th} = 15$ MeV from the lowest value $G_1/G_0 = 0.4$ coming from the calculations of [43, 44]. But they have stressed that the $\Theta^+(1540)$ resonance can be much narrower after the appropriate choice of the G_1/G_0 ratio. In our calculations of the exotic baryon widths, we try to bring the $\Theta^+(1540)$ width into accordance with its estimates coming from the analysis of K^+N and K^+d scattering data [9–12]. For the input $\Theta_\Gamma = 1$ MeV, we obtain $G_1/G_0 = 1.25$. The results of calculations are summarized in Table 2.

Table 2. Mass spectrum and width of exotic baryons

Particle	J	Mass (MeV/c^2)	Γ (MeV/c^2)
anti-decuplet			
Θ	1/2	1540 (input)	1 (input)
$\Xi_{3/2}$	1/2	1862 (input)	19
27-plet			
Θ_1	3/2	1599	62
Σ_2	3/2	1697	164
$\Xi_{3/2}$	3/2	1878	137
Ω_1	3/2	2059	128
Θ_1	1/2	1928	271
Σ_2	1/2	2271	266
$\Xi_{3/2}$	1/2	2272	194
Ω_1	1/2	2273	130
35-plet			
Θ_2	5/2	1839	29
$\Delta_{5/2}$	5/2	1701	164
Σ_2	5/2	1868	127
$\Xi_{3/2}$	5/2	2035	101
Ω_1	5/2	2203	83
Φ	5/2	2370	71

4. Θ_1 Puzzle

We have already mentioned that the predictions of the chiral quark soliton model, as well as of some quark models, about the lowest excitation of the $\Theta^+(1540)$ baryon are probably in conflict with the experimental data for K^+p scattering [45]. Indeed, according to its quantum numbers ($I = 1,\ J = \frac{3}{2}$), the contribution of the predicted resonance $\Theta_1(1599)$) in the total K^+p cross-section is

$$\sigma = \frac{\pi}{k^2}\frac{(2J+1)}{(2j_1+1)(2j_2+1)}\frac{B_{K^+p}\Gamma_{\rm tot}^2}{\left(E_{\rm cm}-M_{\Theta_1}\right)^2+\frac{1}{4}\Gamma_{\rm tot}^2}, \quad (13)$$

where $\Gamma_{\rm tot} = \frac{\Gamma_{K^+p}}{B_{K^+p}}$ is the total resonance width, B_{K^+p} is the branching ratio, k is the momentum in the c.m. frame, and $j_1 = \frac{1}{2}$ and $j_2 = 0$ are proton and kaon spins, respectively. At the resonance peak, it gives

$$\sigma_{|_{\rm peak}} = B_{K^+p} \times \frac{8\pi}{k^2} \approx B_{K^+p} \times 82 \text{ mb}. \quad (14)$$

According to its mass and quantum numbers, Θ_1^{++} has two decay channels

$$\Theta_1^{++} \to K^+p \quad \text{and} \quad K\pi N. \quad (15)$$

It is difficult to estimate the three-body-decay width, but one may expect that it is strongly suppressed by the phase volume (the mass difference between Θ_1 and the final $K\pi N$ system is only 20 MeV/c^2). Taking as "mostly optimistic" branching $B_{K^+p} = 0.5$, one obtains 42 mb in the peak against the experimental value of $12\div15$ mb for the total K^+p cross section at $P_{\rm lab} = 585$ MeV/c [46].

Conclusions

In the framework of the chiral quark soliton model, we calculated the mass spectrum and two-body widths of all exotic penta-quarks. The model parameters were fixed from the mass splitting in the $\frac{1}{2}^+$ octet and the $\frac{3}{2}^+$ decuplet and the assumption that $\Theta^+(1540)$ and $\Xi_{3/2}(1862)$ are members of the anti-decuplet. We show that the model predicts the existence of a new isotriplet of Θ-baryons, Θ_1^{++}, Θ_1^{+}, and Θ_1^0, with hypercharge $Y = 2$ and $J^P = \frac{3}{2}^+$ and mass 1599 MeV/c^2. The triplet of Θ_1 baryons is a member of the 27-dimensional representation of the SU(3) flavour group. The width of this state, in contrast with Θ from the anti-decuplet, is broad. We demonstrate that this prediction of the chiral quark soliton model is in qualitative conflict with experiment which shows no structure in the total K^+p cross section near $P_{\rm lab} = 585$ MeV/c.

The authors thank to Andro Kacharava and Eugene Strokovsky for helpful discussions.

1. *Nakano T. et al.* //Phys. Rev. Lett. — 2003. — **91**. — 012002.
2. *Barmin V.V. et al.* The DIANA collaboration // Phys. Atom. Nucl. — 2003. — **66**. — P. 1715—1718; Yad. Fiz. — 2003. — **66**. — P. 1763—1766 [hep-ex/0304040].
3. *Stepanyan S. et al.* The CLAS collaboration// hep-ex/0307018.
4. *Barth J. et al.* //hep-ex/0307083.
5. *Asratyan A.A., Dolgolenko E.G., Kubantsev M.A.* //hep-ex/0309042.
6. *Kubarovsky V. et al.* //hep-ex/0311046.
7. *Capstick S., Page P.R., Roberts W.* //Phys. Lett. B. — 2003. – **570**. — P. 185—190 [hep-ph/0307019].
8. *Page P.R.* //hep-ph/0310200.
9. *Nussinov S.* //hep-ph/0307357.
10. *Arndt R.A., Strakovsky I.I., Workman R.A.* //Phys. Rev. C. — 2003. — **68**. — 042201 [nucl-th/038012].
11. *Haidenbauer J., Kein G.* //hep-ph/0309243.
12. *Cahn R.N., Trilling G.H.* //hep-ph/0311245.
13. *Alt C. et al.* //hep-ph/0310014.
14. *Jaffe R.L.* SLAC-PUB-1774, Talk presented at the Topical Conf. on Baryon Resonances, Oxford, England, July 5—9, 1976.
15. *Hogaasen H., Sorba P.* //Nucl. Phys. B. — 1978. — **145**. — P. 119.
16. *Strottman D.* //Phys. Rev. D. — 1979. — **20**. — P. 748.
17. *Roiesnel C.* //Ibid. — P. 1646.
18. *Manohar A.* //Nucl. Phys. B. — 1984. — **248**. — P. 19; *Chemtob M.* //Ibid. — 1985. — **256**. — P. 600.
19. *Biedenharn L.C., Dothan Y.* From SU(3) to Gravity (Ne'eman Festschrift). — Cambridge: Univ. Press, 1986.
20. *Praszalowicz M.* Skyrmions and Anomalies /Ed. by. M. Jezabek and M. Praszalowicz. — World Scientific, 1987. — P. 112.
21. *Walliser H.* Baryon as Skyrme Soliton /Ed. by G. Holzwarth. — World Scientific, 1992. — P. 247.
22. *Diakonov D., Petrov V., Polyakov M.* //Z. Phys. A. — 1997. — **359**. — P. 305.
23. *Weigel H.* //Europ. Phys. J. A. — 1998. — **2**. — P. 391.
24. *Praszalowicz M.* //Phys. Lett. B. — 2003. — **575**. — P. 234 [hep-ph/0308114].
25. *Diakonov D., Petrov V.* //hep-ph/0310212.
26. *Walliser H., Kopeliovich V.B.* //J. Exp. Theor. Phys. — 2003. — **97**. — P. 433—440; Zh. Eksp. Teor. Fiz. — 2003. — **124**. — P. 483—490 [hep-ph/0304058].
27. *Borisyuk D., Faber M., Kobushkin A.* //hep-ph/0307370.
28. *Stancu Fl., Riska D.O.* //Phys. Lett. B. — 2003. — **575**. — P. 242—248 [hep-ph/0307010].
29. *Hyodo T., Hosaka A., Oset E.* //nucl-th/0307105.
30. *Jaffe R., Wilczek F.* //hep-ph/0307341.
31. *Karliner M., Lipkin H.J.* //hep-ph/0307341.
32. *Carlson C.E. et al.* //hep-ph/0307396.
33. *Glozman L.Ya.* //Phys. Lett. B. — 2003. — **575**. — P. 18—24 [hep-ph/0308232].
34. *Gerasyuta S.M., Kochkin V.I.* //hep-ph/0310225 and hep-ph/0310227.

35. *Dudek J.J., Close F.E.* //hep-ph/0311258.
36. *Zhu S.L.* //Phys. Rev. Lett. — 2003. — **91**. — 232002 [hep-th/0307345]; *Sugiyama J., Doi T., Oka M.* //hep-ph/0309271.
37. *Csikor F. et al.* //JHEP. — 2003. — **0311**. — 070 [arXiv:hep-lat/0309090]; *Sasaki S.* //hep-lat/0310014.
38. *Witten E.* //Nucl. Phys. B. — 1983. — **223**. — P. 433.
39. *Guadagnini E.* //Ibid. — 1984. — **236**. — P. 35.
40. *Cohen T.* //hep-ph/0309111 and hep-ph/0312191.
41. *Diakonov D., Petrov V.* //hep-ph/0309203.
42. *Praszalowicz M.* //hep-ph/0311230.
43. *Christov C. et al.* //Phys. Lett. B. — 1994. — **325**. — P. 467.
44. *Blotz A., Praszalowicz M., Goeke K.* //Phys. Rev. D. — 1996. – **53**. — P. 219.
45. *Jennings B.K., Maltman K.* //hep-ph/0308286.
46. *Bowen et al.* //Phys. Rev. D. — 1970. — **2**. — P. 2599.

Received 26.12.03

ЕКЗОТИЧНІ БАРІОНИ В КІРАЛЬНІЙ КВАРКОВО-СОЛІТОННІЙ МОДЕЛІ

Д. Борисюк, М. Фабер, О. Кобушкін

Р е з ю м е

Розглядаючи баріонні резонанси $\Theta^+(1540)$ та $\Xi_{3/2}(1860)$ як збудження "солітонної рідини" з SU(3) симетрією $\overline{10}$, ми передбачаємо існування нового мультиплета баріонів Θ_1^{++}, Θ_1^+, Θ_1^0, що належить 27-плету групи SU(3), з гіперзарядом Y=2, ізоспіном I=1 та спіном J=3/2. Маса та ширина Θ_1 оцінені в кіральній кварково-солітонній моделі. Ми показуємо, що розрахована маса $m_{\Theta_1} = 1599$ MeB/c^2 та велика ширина знаходяться в якісному протиріччі з експериментальними даними, що не виявляють ніякої структури у повному перерізі K^+p поблизу $P_{\rm lab} = 585$ MeB/c. Ми також вивчаємо властивості інших екзотичних баріонів із 27- та 35-плетів.