

**The Mass Spectrum of the Exotic Meson 0^{--} ,
 0^{+-} and 2^{+-} States
by the Diquark Cluster Model Calculation
with $q^2 \bar{q}^2$ System**

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12 October 2007

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Table 1. The Mass Spectrum of $I^G(J^{PC}) = 1^-(1^{-+})$ States with the Calculated and Experimental Results.

	Calculated Mass*	Observed Mass*	Γ^*	References
1390	1257±20 ±25	354±64±60	1) E852	
	1272±17	660±48	2) E852	
	1360±25	220±90	3) Crystal	
	1370±16 $^{+50}_{-30}$	385±40 $^{+65}_{-105}$	4) E852	
	1400±20 ±20	310±50 $^{+50}_{-30}$	5) Crystal	
1525				
1585	1.56±0.06**	0.34**±0.05**	6) Ves	
1595	1593±8 $^{+29}_{-47}$	168±20 $^{+150}_{-12}$	7) E852	
	1597±10 $^{+45}_{-10}$	340±40 ±50	8) E852	
	1.6~2.2**		9) E852	
1665	1644±8 ±10	185±25 ±28	10) E852	
1725	1709±24±41	403±80 ±115	11) E852	
1960	2001±30±92	330±52 ±49	11) E852	
2040	2014±20±16	230±32 ±73	10) E852	

* is a unit in MeV and ** is a unit in GeV.

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The mass formula for the Diquark Cluster Model (DCM) based on the Nuclear Shell Model is following .

$$M = m n_T + M(1p_{1/2}) n(1p_{1/2}) + M(1p_{3/2}) n(1p_{3/2}) \\ + M(1d_{3/2}) n(1d_{3/2}) + \Delta_0(n_{\phi_0} + n_{\bar{\phi}_0}) + \Delta_1(n_{\phi_1} + n_{\bar{\phi}_1}) + \Sigma \Delta_{TS}$$

The mass for u and d quark and the parameter of the harmonic oscillator are $m = \omega = 300$ MeV.

And total quark number is $n_T = k + h$, k is quark and h is antiquark number, respectively.

The excitation energy of u or d quark from $1s_{1/2}$ state to $1p_{1/2}$ state and to $1d_{3/2}$ state are $M(1p_{1/2}) = 150$ MeV and $M(1d_{3/2}) = 375$ MeV, respectively.

The interaction in the s state diquark cluster for spin 0 is $\Delta_0 = a - 3/4b$, and for spin 1 is $\Delta_1 = a + 1/4b$, and $a = 187$ MeV, $b = 195$ MeV.

The interaction parameters for the p state quark-quark interaction in the diquark cluster are $\Delta_{00} = \Delta_{11} = \Delta_{01} = 0$, $\Delta_{10} = -60$ MeV.

The first suffix of Δ represents an isospin and second one is a spin respectively¹⁾.

¹⁾ Y.Uehara, N.Konno, H.Nakamura and H.Noya:
Nucl. Phys. A606 (1996) 357

Table 2. The Mass Spectrum of $I^G(J^{PC}) = 0^-(0^{--})$ states.

M(MeV)	Configurations	[TS] combinations
$B^0_{\omega_0}(1390)$	$[(1S_{1/2})^2][(1p_{1/2}) (1S_{1/2})]$	[00][00]
$B^0_{\omega_0}(1585)$	$[(1S_{1/2})^2][(1p_{1/2}) (1S_{1/2})]$	[11][11]
$B^0_{\omega_0}(1725)$	$[(1p_{1/2}) (1S_{1/2})] [(1d_{3/2}) (1S_{1/2})]$	[11][11]
$B^0_{\omega_0}(1735)$	$[(1p_{1/2}) (1S_{1/2})] [(1d_{3/2}) (1S_{1/2})]$	[01][01]

Table 3. The Mass Spectrum of $I^G(J^{PC}) = 1^+(0^{--})$ states.

M(MeV)	Configurations	[TS] combinations
$B^0_{\rho_0}(1330)$	$[(1S_{1/2})^2][(1p_{1/2}) (1S_{1/2})]$	[00][10]
$B^0_{\rho_0}(1585)$	$[(1S_{1/2})^2][(1p_{1/2}) (1S_{1/2})]$	[11][11]
$B^0_{\rho_0}(1595)$	$[(1S_{1/2})^2][(1p_{1/2}) (1S_{1/2})]$	[11][01]
$B^0_{\rho_0}(1725)$	$[(1p_{1/2}) (1S_{1/2})] [(1d_{3/2}) (1S_{1/2})]$	[11][01],[11][11]
$B^0_{\rho_0}(1735)$	$[(1p_{1/2}) (1S_{1/2})] [(1d_{3/2}) (1S_{1/2})]$	[01][11]

Table 4. The Mass Spectrum of $I^G(J^{PC}) = 0^-(0^{+-})$ states.

M(MeV)	Configurations	[TS] combinations
$B^0_{h_0}(1810)$	$[(1S_{1/2})^2][(1d_{3/2}) (1S_{1/2})]$	[11][11]

Table 5. The Mass Spectrum of $I^G(J^{PC}) = 1^+(0^{+-})$ states.

M(MeV)	Configurations	[TS] combinations
$B^0_{b_0}(1440)$	$[(1p_{1/2}) (1S_{1/2})]^2$	[00][10]
$B^0_{b_0}(1510)$	$[(1p_{1/2}) (1S_{1/2})]^2$	[01][11]
$B^0_{b_0}(1810)$	$[(1S_{1/2})^2][(1d_{3/2}) (1S_{1/2})]$	[11][01],[11][11]
$B^0_{b_0}(1950)$	$[(1d_{3/2}) (1S_{1/2})]^2$	[01][11],[02][12]

Table 6. The Mass Spectrum of $I^G(J^{PC}) = 0^-(2^{+-})$ states.

M(MeV)	Configurations	[TS] combinations
$B^0_{h_2}(1615)$	$[(1S_{1/2})^2][(1d_{3/2}) (1S_{1/2})]$	[00][02]
$B^0_{h_2}(1810)$	$[(1S_{1/2})^2][(1d_{3/2}) (1S_{1/2})]$	[11][11],[11][12]
$B^0_{h_2}(1950)$	$[(1d_{3/2}) (1S_{1/2})]^2$	[01][02],[11][12]

Table 7. The Mass Spectrum of $I^G(J^{PC}) = 1^+(2^{+-})$ states.

M(MeV)	Configurations	[TS] combinations
$B^0_{b_2}(1510)$	$[(1p_{1/2}) (1S_{1/2})]^2$	[01][11]
$B^0_{b_2}(1615)$	$[(1S_{1/2})^2][(1d_{3/2}) (1S_{1/2})]$	[00][12]
$B^0_{b_2}(1810)$	$[(1S_{1/2})^2][(1d_{3/2}) (1S_{1/2})]$	[11][01],[11][02],[11][11],[11][12]
$B^0_{b_2}(1950)$	$[(1d_{3/2}) (1S_{1/2})]^2$	[01][11],[01][12],[11][02],[11][12],[02][12]

Table 8. The Mass Spectrum of $I^G(J^{PC}) = 0^+(1^{-+})$ states.

M(MeV)	Configurations	[TS] combinations
$B_{\eta_1}^0(1400)$	$[(1s_{1/2})^2][(1s_{1/2})(1p_{1/2})]$	[00][01]
$B_{\eta_1}^0(1523)$	$[(1s_{1/2})^2][(1s_{1/2})(1p_{1/2})]$	[11][10]
$B_{\eta_1}^0(1585)$	$[(1s_{1/2})^2][(1s_{1/2})(1p_{1/2})]$	[11][11]
$B_{\eta_1}^0(1665)$	$[(1s_{1/2})(1p_{1/2})][(1d_{3/2})(1s_{1/2})]$	[10][11]
$B_{\eta_1}^0(1725)$	$[(1s_{1/2})(1p_{1/2})][(1d_{3/2})(1s_{1/2})]$	[00][01],[11][11],[11][12]
$B_{\eta_1}^0(1735)$	$[(1s_{1/2})(1p_{1/2})][(1d_{3/2})(1s_{1/2})]$	[01][01],[01][02]

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