

Appendix B

STRUCTURE OF KNOWN PARTICLES

The quark and lepton model of particle physics divides charges in quarks to $\pm 2e/3$ and $\pm e/3$. The electrino model of particle physics does not do that. Instead, it divides charges in electrinos to $\pm e$, $\pm e/2$, $\pm e/4$, and $\pm e/8$. The electrino model of particle physics does not hold that the quark and lepton model of particle physics is correct. Nevertheless, to facilitate cross referencing with the existing data, this volume will employ quark model titles and classifications in the subsequent classification of particles.

The chonomic structures contained in the following material are the author's, but the particle data come from C. Amsler *et al.* (Particle Data Group), PL **B667**, 1 (2008) (URL: <http://pdg.lbl.gov>). and S. Eidelman *et al.* (Particle Data Group), Phys Lett B **592** (2004) (URL: <http://pdg.lbl.gov>). The author's chonomic structures in this appendix are induced from the following eight criteria: particle charge, spin, parity, mass, spin feasibility, preceding particles (to avoid duplication), decay schemes, and the Pauli Exclusion Principle. The use of isospin in the precursor data instead of the simple charge made the author's work difficult; so too the convention of listing any charge π as π , and decay products of baryons as $N \dots$, where N can stand for many different baryons. For accurate results, please change to precise reporting conventions. These results are highly valuable, and worth doing right.

This appendix is a draft, and may contain some errors. We hope to find and correct those errors when the masses of all the particles in this appendix are solved for. This appendix proves that all known matter, light, and gravitons can better be constructed of electrinos rather than quarks and leptons. All particles may be formulated with yachons and echons, or with +, -, o's, and ●'s. For the most part, in this appendix, n replaces a ● and a +. The key to understanding chonomics is in Chapter 10.

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Particle state levels are listed at the left side of the chonomic structures. The bottom state level is called 0 or ground state.

In the higher chonomic structures there can appear the symbols n_0 , which do not mean the word no, but neutron and pion.

This document, "Structure of Known Particles," is a necessary adjunct to *Prediction of the Masses of Every Known Particle, Step 2 and Step 3*. The investigator needs to know the particle structures he/she is calculating the masses for.

GAUGE AND HIGGS BOSONS

γ

$$I(J^{PC}) = 0, 1(1^{-})$$

Mass $m < 1 \times 10^{-18}$ eV
 Charge $q < 5 \times 10^{-30}$ e
 Mean life $\tau_\gamma = \text{Stable}$

$$\begin{array}{c} \gamma \\ 0 \\ \hline 2 \quad | \\ 1 \quad \hline 0 \quad \cdot | \cdot \\ \\ \hline 1 | 1 \\ | \end{array}$$

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Higgs Bosons – H^0 and H^\pm , Searches for

H^0 Mass $m > 114.4$ GeV, CL = 95%

H_1^0 In Supersymmetric Models $\left(m_{H_1^0} < m_{H_2^0}\right)$

Mass $m > 92.8$ GeV, CL = 95%

A^0 Pseudoscalar Higgs Boson in Supersymmetric Models

Mass $m > 93.4$ GeV, CL = 95% $\tan\beta > 0.4$

H^\pm Mass $m > 79.3$ GeV, CL = 95%

No formulation in system.

Unknown heavy or light bosons, searches for, are not covered in this appendix.

This appendix covers known particles.

LEPTONS

e

$J = 1/2$

Mass $m = 0.510998910 \pm 0.000000013$ MeV
 $= (548.57990943 \pm 0.00000023) \times 10^{-6}$ u

$(m_{e^+} - m_{e^-}) / m < 8 \times 10^{-8}$, CL = 90%

$|q_{e^+} + q_{e^-}| / e < 4 \times 10^{-8}$

Magnetic moment $\mu = 1.0011596521811 \pm 0.0000000000007$ μ_B

$(g_{e^+} - g_{e^-}) / g_{average} = (-0.5 \pm 2.1) \times 10^{-12}$

Electric dipole moment $d = (0.07 \pm 0.07) \times 10^{-26}$ e cm

Mean life $\tau > 4.6 \times 10^{26}$ yr, CL = 90%

$$\begin{array}{r}
 e \\
 0.510\ 998\ 910\ \text{MeV} \\
 2 \quad | \\
 1 \quad | \\
 0 \quad -| \\
 \\
 0 \quad |^{-1/2} \\
 \quad |
 \end{array}$$

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μ $J = 1/2$
 Mass $m = 105.658367 \pm 0.000004$ MeV
 $= 0.1134289256 \pm 0.0000000029$ u
 Mean life $\tau = (2.197019 \pm 0.000021) \times 10^{-6}$ s ($S = 1.1$)
 Magnetic moment $\mu = 1.0011659208 \pm 0.0000000006$ $e\hbar/2m_\mu$

	μ	
	105.671 929 MeV	
2		
1	-	
0		
	0 $-1/2$	

τ $J = 1/2$
 Mass $m = 1776.84 \pm 0.17$ MeV

	τ	
	1747.03 MeV	
2	-	
1		
0		
	0 $-1/2$	

Neutrinos

ν_e $J = 1/2$
 Mass $m > 0$ MeV
 < 0.000003 MeV

	$\nu_e > 0$	
	0	
2		
1		
0	- 0	
	1 $1/2$	

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ν_μ $J = 1/2$
 Mass $m < 0.19$ MeV, CL = 90%

$$\begin{array}{c} \nu_\mu > 0i \\ 0 \\ 2 \quad \frac{|}{-|} \\ 1 \quad \frac{|}{-|} \\ 0 \quad \frac{|}{o} \\ \\ \frac{1 | 1/2}{|} \end{array}$$

ν_τ $J = 1/2$
 Mass $m < 18.2$ MeV, CL = 95%

$$\begin{array}{c} \nu_\tau > 0i \\ 0 \\ 2 \quad \frac{|}{-|} \\ 1 \quad \frac{|}{-|} \\ 0 \quad \frac{|}{o} \\ \\ \frac{1 | 1/2}{|} \end{array}$$

QUARKS

No formulation of quarks in the electrino system.

ELECTRINOS

See Gordon L. Ziegler and Iris I Koch, *Prediction of the Masses of Every Known Particle (as of 2008) Step 2, Part 1* (<http://benevolententerprises.org> Book List), pp. 17, 18.

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LIGHT UNFLAVORED MESONS
(S = C = B = 0)

π^\pm $I^G(J^P) = 1^-(0^-)$
Mass $m = 139.57018 \pm 0.00035$ MeV (S = 1.2)

$$\begin{array}{r} \pi^+ \\ 137.002 \ 202 \ \text{MeV} \\ 2 \quad | \\ 1 \quad | \\ 0 \quad | \circ \\ \hline 0 \ 0 \\ | \end{array}$$

π^0 $I^G(J^{PC}) = 1^-(0^{-+})$
Mass $m = 134.9766 \pm 0.0006$ MeV (S = 1.1)

$$\begin{array}{r} \pi^0 \\ 137.002 \ 202 \ \text{MeV} \\ 2 \quad | \\ 1 \quad | \\ 0 \quad - \ | - \\ \hline 1 \ 0 \\ | \end{array}$$

η $I^G(J^{PC}) = 0^+(0^{-+})$
Mass $m = 547.853 \pm 0.024$ MeV

$$\begin{array}{r} \eta \\ 548.008 \ 806 \ \text{MeV} \\ 2 \quad | \\ 1 \quad | \\ 0 \quad -+ \ | \ +- \\ \hline 1 \ -1 \ 0 \\ | \end{array}$$

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$$f_0(600) \quad I^G(J^{PC}) = 0^+(0^{++})$$

or σ

Mass $m = (400-1200)$ MeV

$$f_0(600)$$

$$548.008 \quad 807 \quad \text{MeV}$$

$$\begin{array}{c} 2 \quad | \\ 1 \quad | \\ 0 \quad \circ | \circ \end{array}$$

$$\frac{1-1 | 0}{|}$$

$$\rho(770)^\pm \quad I^G(J^{PC}) = 1^+(1^{--})$$

Mass $m = 775.49 \pm 0.34$ MeV

$$\rho^+$$

$$758.084 \quad 547 \quad 1 \quad \text{MeV}$$

$$\begin{array}{c} 2 \quad | \\ 1 \quad | \\ 0 \quad - | \circ - \end{array}$$

$$\frac{1-1 | -1}{|}$$

$$\rho(770)^0 \quad I^G(J^{PC}) = 1^+(1^{--})$$

Mass $m = 775.49 \pm 0.34$ MeV (S = 1.8)

$$\rho^0$$

$$1096.017 \quad 616 \quad \text{MeV}$$

$$\begin{array}{c} 2 \quad | \\ 1 \quad | \\ 0 \quad - \circ | \circ - \end{array}$$

$$\frac{1-1 | -1}{|}$$

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$\omega(782) \quad I^G(J^{PC}) = 0^-(1^{--})$

Mass $m = 782.65 \pm 0.12$ MeV (S = 1.9)

$$\begin{array}{c} \omega(782) \\ ? \\ 2 \quad | \\ 1 \quad | \\ 0 \quad -|+ \\ \hline -1|-1 \\ | \end{array}$$

$\eta'(958) \quad I^G(J^{PC}) = 0^+(0^{+-})$
 Mass $m = 957.66 \pm 0.24$ MeV

$$\begin{array}{c} \eta'(958) \\ ? \\ 2 \quad | \\ 1 \quad | \\ 0 \quad -o|o- \\ \hline 2-1|0 \\ | \end{array}$$

$f_0(980) \quad I^G(J^{PC}) = 0^+(0^{++})$
 Mass $m = 980 \pm 10$ MeV

$$\begin{array}{c} f_0(980) \\ ? \\ 2 \quad | \\ 1 \quad o|o \\ 0 \quad o|o \\ \hline 1-1|0 \\ | \end{array}$$

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$a_0(980) \quad I^G(J^{PC}) = 1^-(0^{++})$
 Mass $m = 984.7 \pm 1.2 \text{ MeV} \quad (S = 1.5)$

$$\begin{array}{r}
 a_0(980) \\
 ? \\
 2 \quad | \\
 \hline
 1 \quad | \\
 \hline
 0 \quad -+ | \circ+- \\
 \\
 \hline
 1-1 | 0 \\
 |
 \end{array}$$

$\phi(1020) \quad I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 1019.455 \pm 0.020 \text{ MeV} \quad (S = 1.1)$

$$\begin{array}{r}
 \phi(1020) \\
 ? \\
 2 \quad | \\
 \hline
 1 \quad -+ \circ | \circ+ \\
 \hline
 0 \quad \circ | \circ- \\
 \\
 \hline
 2-3 | -1 \\
 |
 \end{array}$$

$h_1(1170) \quad I^G(J^{PC}) = 0^-(1^+)$
 Mass $m = 1170 \pm 20 \text{ MeV}$

$$\begin{array}{r}
 h_1(1170) \\
 ? \\
 2 \quad | \\
 \hline
 1 \quad | \\
 \hline
 0 \quad -\circ | \circ- \\
 \\
 \hline
 2 | 1 \\
 |
 \end{array}$$

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$b_1(1235) \quad I^G(J^{PC}) = 1^+(1^{+-})$
 Mass $m = 1229.5 \pm 3.2 \text{ MeV} \quad (S = 1.6)$

$$\begin{array}{r} b_1(1235) \\ ? \\ 2 \quad | \\ \hline 1 \quad | \\ \hline 0 \quad -| \circ + \\ \\ \hline -1 \quad | -1 \\ | \end{array}$$

$a_1(1260) \quad I^G(J^{PC}) = 1^-(1^{+-})$
 Mass $m = 1230 \pm 40 \text{ MeV}$

$$\begin{array}{r} a_1(1260) \\ ? \\ 2 \quad | \\ \hline 1 \quad | \circ \\ \hline 0 \quad -\circ | \circ - \\ \\ \hline 1 - 1 \quad | - 1 \\ | \end{array}$$

$f_2(1270) \quad I^G(J^{PC}) = 0^+(2^{++})$
 Mass $m = 1275.1 \pm 1.2 \text{ MeV} \quad (S = 1.1)$

$$\begin{array}{r} f_2(1270) \\ ? \\ 2 \quad | \\ \hline 1 \quad -\circ | \circ - \\ \hline 0 \quad -\circ | \circ - \\ \\ \hline 2 - 2 \quad | - 2 \\ | \end{array}$$

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$f_1(1285) \quad I^G(J^{PC}) = 0^+(1^{++})$
 Mass $m = 1281.8 \pm 0.6 \text{ MeV} \quad (S = 1.6)$

$$\begin{array}{r} f_1(1285) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{| \circ}{| \circ} \\ 0 \quad \frac{| \circ}{| \circ} \\ \hline 2-2 \quad | \quad -1 \\ | \end{array}$$

$\eta(1295) \quad I^G(J^{PC}) = 0^+(0^+)$
 Mass $m = 1294 \pm 4 \text{ MeV} \quad (S = 1.6)$

$$\begin{array}{r} \eta(1295) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{| \circ}{| \circ} \\ \hline 2-1 \quad | \quad 0 \\ | \end{array}$$

$\pi(1300) \quad I^G(J^{PC}) = 1^-(0^+)$
 Mass $m = 1300 \pm 100 \text{ MeV}$

$$\begin{array}{r} \pi(1300) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{| \circ}{| \circ} \\ 0 \quad \frac{| \circ}{| \circ} \\ \hline 2-1 \quad | \quad 0 \\ | \end{array}$$

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$a_2(1320) \quad \Gamma^G(J^{PC}) = 1^-(2^{+-})$
 Mass $m = 1318.3 \pm 0.6 \text{ MeV}$ (S = 1.2)

$$\begin{array}{r} a_2(1320) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{-|o-}{|} \\ 0 \quad \frac{-o|o-}{|} \\ \hline 2-2|-2 \\ | \end{array}$$

$f_0(1370) \quad \Gamma^G(J^{PC}) = 0^+(0^{++})$
 Mass $m = 1200 \text{ to } 1500 \text{ MeV}$

$$\begin{array}{r} f_0(1370) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{o|o}{|} \\ 0 \quad \frac{-+o|o+-}{|} \\ \hline 2-2|0 \\ | \end{array}$$

$\pi_1(1400) \quad \Gamma^G(J^{PC}) = 1^-(1^{+-})$
 Mass $m = 1351 \pm 30 \text{ MeV}$ (S = 2.0)

$$\begin{array}{r} \pi_1(1400) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-+|o+-}{|} \\ \hline 2-1|1 \\ | \end{array}$$

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$\eta(1405)$ $I^G(J^{PC}) = 0^+(0^+)$
 Mass $m = 1409.8 \pm 2.5$ MeV ($S = 2.2$)

$$\begin{array}{c} \eta(1405) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{-} \\ 0 \quad - | - \\ \hline 2-1 | 0 \\ | \end{array}$$

$f_1(1420)$ $I^G(J^{PC}) = 0^+(1^+)$
 Mass $m = 1426.4 \pm 0.9$ MeV ($S = 1.1$)

$$\begin{array}{c} f_1(1420) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{-} \\ 0 \quad -+ | +- \\ \hline 1-2 | -1 \\ | \end{array}$$

$\omega(1420)$ $I^G(J^{PC}) = 0^-(1^-)$
 Mass $m = 1400 \pm 1450$ MeV

$$\begin{array}{c} \omega(1420) \\ ? \\ 2 \quad | \\ 1 \quad | \\ 0 \quad -\circ | \circ+ \\ \hline 1-2 | -1 \\ | \end{array}$$

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$a_0(1450)$ $I^G(J^{PC}) = 1^-(0^{++})$
 Mass $m = 1474 \pm 19$ MeV

$$\begin{array}{r}
 a_0(1450) \\
 ? \\
 2 \quad | \\
 1 \quad \frac{\circ | \circ}{|} \\
 0 \quad -+ | +- \\
 \hline
 2-2 | 0 \\
 |
 \end{array}$$

$\rho(1450)$ $I^G(J^{PC}) = 1^+(1^{--})$
 Mass $m = 1465 \pm 25$ MeV

$$\begin{array}{r}
 \rho(1450) \\
 ? \\
 2 \quad | \\
 1 \quad \frac{- | -}{|} \\
 0 \quad | \circ \\
 \hline
 1-1 | -1 \\
 |
 \end{array}$$

$\eta(1475)$ $I^G(J^{PC}) = 0^+(0^{+-})$
 Mass $m = 1476 \pm 4$ MeV (S = 1.3)

$$\begin{array}{r}
 \eta(1475) \\
 ? \\
 2 \quad | \\
 1 \quad \frac{\circ | \circ}{|} \\
 0 \quad + | + \\
 \hline
 -2+1 | 0 \\
 |
 \end{array}$$

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$$f_0(1500) \quad \Gamma^G(J^{PC}) = 0^+(0^{++})$$

$$\text{Mass } m = 1505 \pm 6 \text{ MeV} \quad (S = 1.3)$$

$$\begin{array}{c}
 f_0(1500) \\
 ? \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{0|0}{|} \\
 0 \quad \frac{-+0|0+-}{|} \\
 \\
 \frac{2-2|0}{|}
 \end{array}$$

$$f_2'(1525) \quad \Gamma^G(J^{PC}) = 0^+(2^{++})$$

$$\text{Mass } m = 1525 \pm 5 \text{ MeV}$$

$$\begin{array}{c}
 f_2'(1525) \\
 ? \\
 2 \quad \frac{0|0}{|} \\
 1 \quad \frac{-|-}{|} \\
 0 \quad \frac{-0|0-}{|} \\
 \\
 \frac{2-2|-2}{|}
 \end{array}$$

$$\pi_1(1600) \quad \Gamma^G(J^{PC}) = 1^-(1^{+-})$$

$$\text{Mass } m = 1662_{-11}^{+15} \text{ MeV} \quad (S = 1.2)$$

$$\begin{array}{c}
 \pi_1(1600) \\
 ? \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{+|+}{|} \\
 0 \quad \frac{+|0+}{|} \\
 \\
 \frac{1-2|1}{|}
 \end{array}$$

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$$\eta_2(1645) \quad I^G(J^{PC}) = 0^+(2^{++})$$

$$\text{Mass } m = 1617 \pm 5 \text{ MeV} \quad (S = 1.6)$$

$$\begin{array}{c} \eta(1645) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{\quad} \\ 0 \quad + | + \\ \hline 2-1 | 2 \\ | \end{array}$$

$$\omega(1650) \quad I^G(J^{PC}) = 0^-(1^{--})$$

$$\text{Mass } m = 1670 \pm 30 \text{ MeV}$$

$$\begin{array}{c} \omega(1650) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{\quad} \\ 0 \quad -\circ | \circ+ \\ \hline 1-2 | -1 \\ | \end{array}$$

$$\omega_3(1670) \quad I^G(J^{PC}) = 0^-(3^{--})$$

$$\text{Mass } m = 1667 \pm 4 \text{ MeV}$$

$$\begin{array}{c} \omega_3(1670) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{\quad} \\ 0 \quad -\circ | \circ+ \\ \hline -3 | -3 \\ | \end{array}$$

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$\pi_2(1670)$ $I^G(J^{PC}) = 1^-(2^{-+})$
 Mass $m = 1672.4 \pm 3.2$ MeV

$$\begin{array}{c} \pi_2(1670) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{|} \\ 0 \quad \frac{-\circ | \circ -}{|} \\ \\ \frac{1-2 | -2}{|} \end{array}$$

$\phi(1680)$ $I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 1680 \pm 20$ MeV

$$\begin{array}{c} \phi(1680) \\ ? \\ 2 \quad | \\ 1 \quad \frac{\circ | \circ}{|} \\ 0 \quad \frac{- | -}{|} \\ \\ \frac{2 | 1}{|} \end{array}$$

$\rho_3(1690)$ $I^G(J^{PC}) = 1^+(3^{--})$
 Mass $m = 1688.8 \pm 2.1$ MeV

$$\begin{array}{c} \rho_3(1690) \\ ? \\ 2 \quad \frac{- | -}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{\circ | \circ}{|} \\ \\ \frac{1-3 | -3}{|} \end{array}$$

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$\rho(1700)$ $\Gamma^G(J^{PC}) = 1^+(1^{--})$
 Mass $m = 1720 \pm 20$ MeV

$$\begin{array}{c} \rho(1700) \\ ? \\ 2 \quad \frac{-|-}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{0|0}{|} \\ \\ \frac{1-1|-1}{|} \end{array}$$

$f_j(1710)$ $\Gamma^G(J^{PC}) = 0^+(0^{++})$
 Mass $m = 1724 \pm 7$ MeV (S = 1.5)

$$\begin{array}{c} f_j(1710) \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{0|0}{|} \\ 0 \quad \frac{-+0|0+-}{|} \\ \\ \frac{2-2|0}{|} \end{array}$$

$\pi(1800)$ $\Gamma^G(J^{PC}) = 1^-(0^{-+})$
 Mass $m = 1816 \pm 14$ MeV (S = 2.3)

$$\begin{array}{c} \pi(1800) \\ ? \\ 2 \quad \frac{|0}{|} \\ 1 \quad \frac{0|0}{|} \\ 0 \quad \frac{-+0|0+-}{|} \\ \\ \frac{2-2|0}{|} \end{array}$$

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$\phi_3(1850)$ $I^G(J^{PC}) = 0^-(3^{--})$
 Mass $m = 1854 \pm 7$ MeV

	$\phi_3(1850)$
	?
2	$\frac{ }{ }$
1	$\frac{0 0}{ }$
0	$- -$
	$\frac{-2 -3}{ }$

$\pi_2(1880)$ $I^G(J^{PC}) = 1^-(2^{+-})$
 Mass $m = 1895 \pm 16$ MeV

	$\phi_3(1880)$
	?
2	$\frac{ 0}{ }$
1	$\frac{0 0}{ }$
0	$-+0 0+-$
	$\frac{4-2 2}{ }$

$f_2(1950)$ $I^G(J^{PC}) = 0^+(2^{++})$
 Mass $m = 1944 \pm 12$ MeV (S = 1.5)

	$f_2(1950)$
	?
2	$\frac{ }{ }$
1	$\frac{-0 0-}{ }$
0	$-0 0-$
	$\frac{2-2 -2}{ }$

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$$f_2(2010) \quad I^G(J^{PC}) = 0^+(2^{++})$$

$$\text{Mass } m = 2011_{-80}^{+60} \text{ MeV}$$

$$f_2(2010)$$

$$?$$

$$2 \quad \frac{\quad | \quad}{\quad}$$

$$1 \quad \frac{+o | o+}{\quad}$$

$$0 \quad \frac{+o | o+}{\quad}$$

$$\frac{2-2 | 2}{\quad}$$

$$a_4(2040) \quad I^G(J^{PC}) = 1^-(4^{++})$$

$$\text{Mass } m = 2020 \pm 16 \text{ MeV}$$

$$a_4(2040)$$

$$?$$

$$2 \quad \frac{\quad | o}{\quad}$$

$$1 \quad \frac{-o | o-}{\quad}$$

$$0 \quad \frac{-o | o-}{\quad}$$

$$\frac{1-3 | -4}{\quad}$$

$$f_4(2050) \quad I^G(J^{PC}) = 0^+(4^{++})$$

$$\text{Mass } m = 2018 \pm 2.1 \text{ MeV} \quad (S = 2.1)$$

$$f_4(2050)$$

$$?$$

$$2 \quad \frac{\quad | \quad}{\quad}$$

$$1 \quad \frac{o | o}{\quad}$$

$$0 \quad \frac{-+o | o+-}{\quad}$$

$$\frac{-4 | -4}{\quad}$$

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$$\begin{array}{l}
 f_2(2300) \quad I^G(J^{PC}) = 0^+(2^{++}) \\
 \text{Mass } m = 2297 \pm 28 \text{ MeV} \\
 f_2(2300) \\
 ? \\
 \begin{array}{r}
 2 \quad | \\
 \hline
 1 \quad | \circ \\
 \hline
 0 \quad -+ \circ | \circ +- \\
 \hline
 1-3 \quad | \quad -2 \\
 \hline
 |
 \end{array}
 \end{array}$$

$$\begin{array}{l}
 f_2(2340) \quad I^G(J^{PC}) = 0^+(2^{++}) \\
 \text{Mass } m = 2339 \pm 60 \text{ MeV} \\
 ? \\
 \begin{array}{r}
 2 \quad | \\
 \hline
 1 \quad | \circ \\
 \hline
 0 \quad -+ \circ | \circ +- \\
 \hline
 1-3 \quad | \quad -2 \\
 \hline
 |
 \end{array}
 \end{array}$$

This appears to be the identical particle as $f_2(2300)$. It has the same characteristics, the same decay products, and the mass of $f_2(2300)$ is within the error bar of the mass of $f_2(2340)$.

STRANGE MESONS
($S = \pm 1, C = B = 0$)

$$\begin{array}{l}
 K^\pm \quad I(J^P) = \frac{1}{2}(0^-) \\
 \text{Mass } m = 493.677 \pm 0.016 \text{ MeV} \quad (S = 2.8) \\
 K^\pm \\
 ? \\
 \begin{array}{r}
 2 \quad | \\
 \hline
 1 \quad | \circ \\
 \hline
 0 \quad | \\
 \hline
 0 \quad | \quad 0 \\
 \hline
 |
 \end{array}
 \end{array}$$

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$$K_S^0 \quad I(J^P) = \frac{1}{2}(0^-)$$

Mass $m = 497.614 \pm 0.024$ MeV (S = 1.6)

$$\begin{array}{c}
 K_S^0 \\
 ? \\
 2 \quad | \\
 1 \quad -| \\
 0 \quad | \\
 \hline
 1 \quad | \quad 0 \\
 |
 \end{array}$$

$$K_L^0 \quad I(J^P) = \frac{1}{2}(0^-)$$

Mass $m = 497.614 \pm 0.024$ MeV (S = 1.6)

$$\begin{array}{c}
 K_L^0 \\
 ? \\
 2 \quad | \\
 1 \quad -| \\
 0 \quad | - \\
 \hline
 1 \quad | \quad 0 \\
 |
 \end{array}$$

$$K^*(892)^\pm \quad I(J^P) = \frac{1}{2}(1^-)$$

Mass $m = 891.66 \pm 0.26$ MeV

$$\begin{array}{c}
 K^*(892)^+ \\
 ? \\
 2 \quad | \\
 1 \quad | \quad 0 \\
 0 \quad -| \\
 \hline
 1-1 \quad | \quad -1 \\
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 454

$$K^*(892)^0 \quad I(J^P) = \frac{1}{2}(1^-)$$

$$\text{Mass } m = 896.00 \pm 0.25 \text{ MeV} \quad (S = 1.4)$$

$$\begin{array}{c}
 K^*(892)^0 \\
 ? \\
 2 \quad | \\
 1 \quad \hline | 0 \\
 0 \quad \circ | \\
 \\
 \hline
 -1 \quad | \quad -1 \\
 |
 \end{array}$$

$$K_1(1270) \quad I(J^P) = \frac{1}{2}(1^+)$$

$$\text{Mass } m = 1272 \pm 7 \text{ MeV}$$

$$\begin{array}{c}
 K_1(1270) \\
 ? \\
 2 \quad | \\
 1 \quad \hline | 0 \\
 0 \quad -\circ | + \\
 \\
 \hline
 1-2 \quad | \quad -1 \\
 |
 \end{array}$$

$$K_1(1400) \quad I(J^P) = \frac{1}{2}(1^+)$$

$$\text{Mass } m = 1403 \pm 7 \text{ MeV}$$

$$\begin{array}{c}
 K_1(1400) \\
 ? \\
 2 \quad | \\
 1 \quad \hline | 0 \\
 0 \quad -\circ | - \\
 \\
 \hline
 1-1 \quad | \quad -1 \\
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 455

$K^*(1410) \quad I(J^P) = \frac{1}{2}(1^-)$
 Mass $m = 1414 \pm 15 \text{ MeV} \quad (S = 1.3)$

	$K^*(1410)$
	?
2	
1	○ ○
0	○ ○
	1-2 -1

$K_0^*(1430) \quad I(J^P) = \frac{1}{2}(0^+)$
 Mass $m = 1425 \pm 50 \text{ MeV}$

	$K_0^*(1430)$
	?
2	
1	○
0	○
	1-1 0

$K_2^*(1430)^+ \quad I(J^P) = \frac{1}{2}(2^+)$
 Mass $m = 1425.6 \pm 1.5 \text{ MeV} \quad (S = 1.1)$

	$K_2^*(1430)^+$
	?
2	
1	- ○-
0	- -
	1-1 -2

APP. B: STRUCTURE OF KNOWN PARTICLES 456

$$K_2^*(1430)^0 \quad I(J^P) = \frac{1}{2}(2^+)$$

$$\text{Mass } m = 1432.4 \pm 1.3 \text{ MeV}$$

$$\begin{array}{c}
 K_2^*(1430)^0 \\
 ? \\
 \begin{array}{c}
 2 \quad | \\
 1 \quad \frac{-|0-}{-} \\
 0 \quad -0|- \\
 \hline
 2-2|-2 \\
 |
 \end{array}
 \end{array}$$

$$K^*(1680) \quad I(J^P) = \frac{1}{2}(1^-) \quad \text{Mass } m = 1717 \pm 27 \text{ MeV} \quad (S = 1.4)$$

$$\begin{array}{c}
 K^*(1680) \\
 ? \\
 \begin{array}{c}
 2 \quad | \\
 1 \quad \frac{0|0}{-} \\
 0 \quad -0|0- \\
 \hline
 1-1|-1 \\
 |
 \end{array}
 \end{array}$$

$$K_2(1770) \quad I(J^P) = \frac{1}{2}(2^-) \quad \text{Mass } m = 1773 \pm 8 \text{ MeV}$$

$$\begin{array}{c}
 K_2(1770) \\
 ? \\
 \begin{array}{c}
 2 \quad | \\
 1 \quad \frac{0|0}{-} \\
 0 \quad -0|0- \\
 \hline
 1-2|-2 \\
 |
 \end{array}
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 457

$$K_3^*(1780) \quad I(J^P) = \frac{1}{2}(3^-)$$

$$\text{Mass } m = 1776 \pm 7 \text{ MeV} \quad (S = 1.1)$$

$$\begin{array}{c}
 K_3^*(1780) \\
 ? \\
 \frac{2}{\quad |} \\
 \frac{1}{\quad | \circ} \\
 \frac{0}{- \circ | -} \\
 \hline
 \frac{-2 | -3}{\quad |}
 \end{array}$$

$$K_2(1820) \quad I(J^P) = \frac{1}{2}(2^-)$$

$$\text{Mass } m = 1816 \pm 13 \text{ MeV}$$

$$\begin{array}{c}
 K_2(1820) \\
 ? \\
 \frac{2}{\quad |} \\
 \frac{1}{\quad | \circ} \\
 \frac{0}{- \circ | -} \\
 \hline
 \frac{1-2 | -2}{\quad |}
 \end{array}$$

$$K_4^*(2045) \quad I(J^P) = \frac{1}{2}(4^+)$$

$$\text{Mass } m = 2045 \pm 9 \text{ MeV} \quad (S = 1.1)$$

$$\begin{array}{c}
 K_4^*(2045) \\
 ? \\
 \frac{2}{\quad |} \\
 \frac{1}{- \circ | \circ -} \\
 \frac{0}{- \circ | \circ -} \\
 \hline
 \frac{-2 | -4}{\quad |}
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 458

CHARMED MESONS
(C = ± 1)

D^\pm $I(J^P) = \frac{1}{2}(0^-)$
Mass $m = 1869.62 \pm 0.20$ MeV (S = 1.1)

	D^+
	?
2	$\frac{- 0}{-}$
1	$\frac{- }{-}$
0	$\frac{- }{-}$
	$\frac{0 0}{-}$

D^0 $I(J^P) = \frac{1}{2}(0^-)$
Mass $m = 1864.84 \pm 0.17$ MeV (S = 1.1)

	D^0
	?
2	$\frac{- -}{-}$
1	$\frac{- }{-}$
0	$\frac{- }{-}$
	$\frac{1 0}{-}$

$D^*(2007)^0$ $I(J^P) = \frac{1}{2}(1^-)$ I, J, P need confirmation
Mass $m = 2006.97 \pm 0.19$ MeV (S = 1.1)

	$D^*(2007)^0$
	?
2	$\frac{- -}{-}$
1	$\frac{- }{-}$
0	$\frac{- -}{-}$
	$\frac{1 -1}{-}$

APP. B: STRUCTURE OF KNOWN PARTICLES 459

$D^*(2010)^{\pm}$ $I(J^P) = \frac{1}{2}(1^-)$ I, J, P need confirmation.

Mass $m = 2010.27 \pm 0.17$ MeV (S = 1.1)

$$\begin{array}{c}
 D^*(2010)^{\pm} \\
 ? \\
 2 \quad \frac{|0}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{-|}{-|} \\
 \\
 \frac{1-1|-1}{|}
 \end{array}$$

$D_1(2420)^0$ $I(J^P) = \frac{1}{2}(1^+)$ I, J, P need confirmation.

Mass $m = 2422.3 \pm 1.3$ MeV (S = 1.2)

$$\begin{array}{c}
 D_1(2420)^0 \\
 ? \\
 2 \quad \frac{-|-}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{0|0}{|} \\
 \\
 \frac{1-1|-1}{|}
 \end{array}$$

$D_2^*(2460)^0$ $I(J^P) = \frac{1}{2}(2^+)$ $J^P = 2^+$ assignment strongly favored.

Mass $m = 2461.1 \pm 1.6$ MeV (S = 1.3)

$$\begin{array}{c}
 D_2^*(2460)^0 \\
 ? \\
 2 \quad \frac{-|-}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{-|-}{|} \\
 \\
 \frac{1-1|-2}{|}
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 460

$D_2^*(2460)^+$ $I(J^P) = \frac{1}{2}(2^+)$ $J^P = 2^+$ assignment strongly favored.

Mass $m = 2460.1_{-3.5}^{+2.6}$ MeV ($S = 1.5$)

$D_2^*(2460)^+$

?

2	o
1	-
0	- -

$\frac{-1|-2}{|}$

CHARMED, STRANGE MESONS
($C = S = \pm 1$)

D_S^\pm
was F^\pm

$I(J^P) = 0(0)$

Mass $m = 1968.49 \pm 0.34$ MeV ($S = 1.3$)

D_S^+

2	o
1	- -
0	

$\frac{2-1|0}{|}$

$D_S^{*\pm}$ $I(J^P) = 0(?^?)$ J^P is natural, width and decay modes consistent with 1^-

Mass $m = 2112.3 \pm 0.5$ MeV ($S = 1.1$)

D_S^{*+}

2	o
1	- -
0	- -

$\frac{2-1|-1}{|}$

APP. B: STRUCTURE OF KNOWN PARTICLES 461

$$D_{s0}^*(2317)^\pm \quad I(J^P) = 0(0^+) \quad J, P \text{ need confirmation.}$$

$$\text{Mass } m = 2317.8 \pm 0.6 \text{ MeV} \quad (S = 1.1)$$

$$D_{s0}^*(2317)^+$$

$$\begin{array}{r} ? \\ 2 \quad \frac{| \circ}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \circ | \end{array}$$

$$\frac{1-1 | 0}{|}$$

$$D_{s1}(2460)^\pm \quad I(J^P) = 0(1^+)$$

$$\text{Mass } m = 2459.6 \pm 0.6 \text{ MeV} \quad (S = 1.1)$$

$$D_{s0}^*(2460)^+$$

$$\begin{array}{r} ? \\ 2 \quad \frac{| \circ}{|} \\ 1 \quad \frac{-|}{|} \\ 0 \quad | \end{array}$$

$$\frac{1-1 | 0}{|}$$

$$D_{s1}(2536)^\pm \quad I(J^P) = 0(1^+) \quad J, P \text{ need confirmation.}$$

$$\text{Mass } m = 2535.35 \pm 0.34 \text{ MeV}$$

$$D_{s1}(2536)^+$$

$$\begin{array}{r} ? \\ 2 \quad \frac{| \circ}{|} \\ 1 \quad \frac{-|}{|} \\ 0 \quad | \end{array}$$

$$\frac{2-2 | -1}{|}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 463

B^0 $I(J^P) = \frac{1}{2}(0^-)$ I, J, P need confirmation. Quantum numbers shown are
 Mass $m = 5279.53 \pm 0.33$ MeV quark-model predictions.

	B^0
	?
3	$\frac{- -}{ }$
2	$\frac{ }{ }$
1	$\frac{ }{ }$
0	$\frac{ }{ }$
	$\frac{1 0}{ }$

B^* $I(J^P) = \frac{1}{2}(1^-)$ I, J, P need confirmation. Quantum numbers shown are
 Mass $m = 5325.1 \pm 0.5$ MeV quark-model predictions.

	B^*
	?
3	$\frac{ 0}{ }$
2	$\frac{ }{ }$
1	$\frac{ }{ }$
0	$\frac{- -}{ }$
	$\frac{1-1 -1}{ }$

$B_1(5721)^0$ $I(J^P) = \frac{1}{2}(1^+)$ I, J, P need confirmation.
 Mass $m = 5720.7 \pm 0.5$ MeV

	$B_1(5721)^0$
	?
3	$\frac{0 0}{ }$
2	$\frac{ }{ }$
1	$\frac{ }{ }$
0	$\frac{- -}{ }$
	$\frac{1-1 -1}{ }$

APP. B: STRUCTURE OF KNOWN PARTICLES 464

$B_2^*(5747)^0$ $I(J^P) = 1/2(2^+)$ I, J, P need confirmation.

Mass $m = 5746.9 \pm 2.9$ MeV

$B_2^*(5747)^0$

?

3 $\frac{0|0}{0|0}$
 2 $\frac{0|0}{|}$
 1 $\frac{|}{-|-}$
 0 $\frac{-|-}{|}$

$\frac{3|2}{|}$

APP. B: STRUCTURE OF KNOWN PARTICLES 465

BOTTOM, STRANGE MESONS
(B = ±1, S = ∓1)

B_S^0 I(J^P) = 0(0⁻) I, J, P need confirmation. Quantum numbers
Mass m = 5366.3 ± 0.6 MeV shown are quark-model
predictions.

$$\begin{array}{c}
 B_S^0 \\
 ? \\
 3 \quad | \circ \\
 \hline
 2 \quad | \\
 \hline
 1 \quad \circ | \\
 \hline
 0 \quad | \\
 \\
 \hline
 0 | 0 \\
 \hline
 |
 \end{array}$$

B_S^* I(J^P) = 0(1⁻) I, J, P need confirmation. Quantum numbers
Mass m = 5412.8 ± 1.3 MeV shown are quark-model
predictions.

$$\begin{array}{c}
 B_S^* \\
 ? \\
 3 \quad - | - \\
 \hline
 2 \quad | \\
 \hline
 1 \quad - | - \\
 \hline
 0 \quad - | - \\
 \\
 \hline
 2 | - 1 \\
 \hline
 |
 \end{array}$$

$B_{s1}(5830)^0$ I(J^P) = ½(1⁺) I, J, P need confirmation.
Mass m = 5829.4 ± 0.7 MeV

$$\begin{array}{c}
 B_{s1}(5830)^0 \\
 ? \\
 3 \quad \circ | \circ \\
 \hline
 2 \quad | \\
 \hline
 1 \quad - | - \\
 \hline
 0 \quad - | - \\
 \\
 \hline
 2-1 | - 1 \\
 \hline
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 466

$B_{s2}^* (5840)^0$ $I(J^P) = \frac{1}{2}(2^+)$ I, J, P need confirmation.
 Mass $m = 5839.7 \pm 0.6$ MeV

$$B_{s1} (5840)^0$$

	?
3	$\frac{0 0}{ }$
2	$\frac{ }{ -}$
1	$\frac{ }{ -}$
0	$\frac{ }{ -}$

$$\frac{2-2|-2}{|}$$

BOTTOM, CHARMED MESONS
(B = C = ± 1)

B_c^\pm $I(J^P) = 0(0^-)$ I, J, P need confirmation. Quantum numbers shown
 Mass $m = 6276 \pm 4$ MeV are quark-model predictions.

$$B_c^+$$

	?
3	$\frac{ 0}{ }$
2	$\frac{ }{ -}$
1	$\frac{ }{ -}$
0	$\frac{ }{ -}$

$$\frac{1|0}{|}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 467

$\bar{c}c$ MESONS

$\eta_c(1S)$ $I^G(J^{PC}) = 0^+(0^{-+})$
 Mass $m = 2980.3 \pm 1.2$ MeV (S = 1.7)

	$\eta_c(1S)$
	?
2	$\frac{0 0}{ }$
1	$\frac{ }{ }$
0	$\frac{ }{ }$
	$\frac{1-1 0}{ }$

$J/\psi(1S)$ $I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 3096.916 \pm 0.011$ MeV

	$J/\psi(1S)$
	?
2	$\frac{0 0}{ }$
1	$\frac{ }{ }$
0	$\frac{- +}{ }$
	$\frac{1-2 -1}{ }$

$\chi_{c0}(1P)$ $I^G(J^{PC}) = 0^+(0^{++})$
 Mass $m = 3414.75 \pm 0.31$ MeV

	$\chi_{c0}(1P)$
	?
2	$\frac{0 0}{ }$
1	$\frac{ }{ }$
0	$\frac{0 0}{ }$
	$\frac{1-1 0}{ }$

APP. B: STRUCTURE OF KNOWN PARTICLES 468

$\chi_{c1}(1P)$ $I^G(J^{PC}) = 0^+(1^{++})$
 Mass $m = 3510.66 \pm 0.07$ MeV

$$\begin{array}{c} \chi_{c1}(1P) \\ ? \\ 2 \quad \frac{0|0}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-0|-}{|} \\ \\ \frac{2-2|-1}{|} \end{array}$$

$h_c(1P)$ $I^G(J^{PC}) = ?^2(1^+)$
 Mass $m = 3525.93 \pm 0.27$ MeV (S = 1.5)

$$\begin{array}{c} h_c(1P) \\ ? \\ 2 \quad \frac{0|0}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-|-}{|} \\ \\ \frac{1-1|-1}{|} \end{array}$$

$\chi_{c2}(1P)$ $I^G(J^{PC}) = 0^+(2^{++})$
 Mass $m = 3556.20 \pm 0.09$ MeV

$$\begin{array}{c} \chi_{c2}(1P) \\ ? \\ 2 \quad \frac{0|0}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{--|--}{|} \\ \\ \frac{2-2|-2}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 469

$$\eta_c(2S) \quad I^G(J^{PC}) = 0^+(0^{-+})$$

Mass $m = 3637 \pm 4$ MeV (S = 1.7)

$$\begin{array}{c} \eta_c(2S) \\ ? \\ 2 \quad \frac{o|o}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-+|+-}{|} \\ \hline 2-2|0 \\ | \end{array}$$

$$\psi(2S) \quad I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 3686.09 \pm 0.04$ MeV (S = 1.6)

$$\begin{array}{c} \psi(2S) \\ ? \\ 2 \quad \frac{o|o}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-o|o+}{|} \\ \hline 1-2|-1 \\ | \end{array}$$

$$\psi(3770) \quad I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 3772.92 \pm 0.35$ MeV (S = 1.1)

$$\begin{array}{c} \psi(3770) \\ ? \\ 2 \quad \frac{o|o}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{+o|o-}{|} \\ \hline 1-2|-1 \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 470

$$\chi(3872) \quad I^G(J^{PC}) = 0^2(\eta^{2+})$$

Mass $m = 3872.2 \pm 0.8 \text{ MeV}$ (S = 2.5)

$$\chi(3872)$$

$$\begin{array}{c} ? \\ 2 \quad \frac{0|0}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-0|0+}{|} \\ \\ \frac{-3|-3}{|} \end{array}$$

$$\psi(4040) \quad I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 4039 \pm 1 \text{ MeV}$

$$\psi(4040)$$

$$\begin{array}{c} ? \\ 2 \quad \frac{-+|+-}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{|}{|} \\ \\ \frac{1-2|-1}{|} \end{array}$$

$$\psi(4160) \quad I^G(J^{PC}) = 0^-(1^{--})$$

Mass $m = 4159 \pm 20 \text{ MeV}$

$$\psi(4160)$$

$$\begin{array}{c} ? \\ 2 \quad \frac{-+|+-}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{-0|0-}{|} \\ \\ \frac{2-2|-1}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 471

$$\chi(4260) \quad I^G(J^{PC}) = ?^?(1^{--})$$

$$\text{Mass } m = 4263_{-9}^{+8} \text{ MeV} \quad (S = 1.1)$$

$$\chi(4260)$$

$$\begin{array}{c} ? \\ 2 \quad \frac{-+ | +-}{|} \\ 1 \quad \frac{\quad |}{|} \\ 0 \quad \frac{\circ | \circ}{|} \end{array}$$

$$\frac{1-2 | -1}{|}$$

$$\psi(4415) \quad I^G(J^{PC}) = 0^-(1^{--})$$

$$\text{Mass } m = 4421 \pm 4 \text{ MeV}$$

$$\psi(4415)$$

$$\begin{array}{c} ? \\ 2 \quad \frac{-+ | +-}{|} \\ 1 \quad \frac{\quad |}{|} \\ 0 \quad \frac{\circ | \circ}{|} \end{array}$$

$$\frac{2-1 | 1}{|}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 472

$b\bar{b}$ MESONS

Y(1S) $I^G(J^{PC}) = 0^-(1^-)$
 Mass $m = 9460.30 \pm 0.26$ MeV (S = 3.3)

Y(1S)
 ?

3	o o
2	
1	
0	-o o+

<u>1-2</u>	<u>-1</u>

$\chi_{b0}(1P)$ $I^G(J^{PC}) = 0^+(0^{++})$ J needs confirmation.
 Mass $m = 9859.44 \pm 0.42$ MeV

$\chi_{b0}(1P)$
 ?

3	o o
2	
1	
0	o o

<u>1-1</u>	<u>0</u>

APP. B: STRUCTURE OF KNOWN PARTICLES 473

$\chi_{b1}(1P)$ $I^G(J^{PC}) = 0^+(1^{++})$ J needs confirmation.

Mass $m = 9892.78 \pm 0.26$ MeV

$$\begin{array}{r} \chi_{b1}(1P) \\ ? \\ 3 \quad \frac{\circ | \circ}{\quad} \\ 2 \quad \frac{\quad | \quad}{\quad} \\ 1 \quad \frac{\quad | \quad}{\quad} \\ 0 \quad \frac{-\circ | \circ -}{\quad} \\ \\ \frac{2-2 | -1}{\quad} \end{array}$$

$\chi_{b2}(1P)$ $I^G(J^{PC}) = 0^+(2^{++})$ J needs confirmation.

Mass $m = 9912.21 \pm 0.26$ MeV

$$\begin{array}{r} \chi_{b2}(1P) \\ ? \\ 3 \quad \frac{\circ | \circ}{\quad} \\ 2 \quad \frac{\quad | \quad}{\quad} \\ 1 \quad \frac{\quad | \quad}{\quad} \\ 0 \quad \frac{-\circ | \circ -}{\quad} \\ \\ \frac{1-2 | -2}{\quad} \end{array}$$

$Y(2S)$ $I^G(J^{PC}) = 0^-(1^{-})$
Mass $m = 10.02326 \pm 0.00031$ GeV

$$\begin{array}{r} Y(2S) \\ ? \\ 3 \quad \frac{\circ | \circ}{\quad} \\ 2 \quad \frac{\quad | \quad}{\quad} \\ 1 \quad \frac{- | -}{\quad} \\ 0 \quad \frac{- | -}{\quad} \\ \\ \frac{2-1 | -1}{\quad} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 474

$\chi_{b0}(2P)$ $I^G(J^{PC}) = 0^+(0^{++})$ J needs confirmation.

Mass $m = 10.2325 \pm 0.0005$ GeV

$$\begin{array}{r} \chi_{b0}(2P) \\ ? \\ 3 \quad \frac{0|0}{|} \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad -+|+- \\ \\ \frac{2-2|0}{|} \end{array}$$

$\chi_{b1}(2P)$ $I^G(J^{PC}) = 0^+(1^{++})$ J needs confirmation.

Mass $m = 10.25546 \pm 0.00022$ GeV

$$\begin{array}{r} \chi_{b1}(2P) \\ ? \\ 3 \quad \frac{0|0}{|} \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad -|- \\ \\ \frac{1-1|-1}{|} \end{array}$$

$\chi_{b2}(2P)$ $I^G(J^{PC}) = 0^+(2^{++})$ J needs confirmation.

Mass $m = 10.26865 \pm 0.00022$ GeV

$$\begin{array}{r} \chi_{b2}(2P) \\ ? \\ 3 \quad \frac{0|0}{|} \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{-|-}{|} \\ 0 \quad -|- \\ \\ \frac{2-2|-2}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 475

Y(3S) $I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 10.3553 \pm 0.0005$ GeV
 Y(3S)
 ?
 3 $\frac{0|0}{|}$
 2 $\frac{|}{|}$
 1 $\frac{|}{|}$
 0 $-+|+-$

 $\frac{1-2|-1}{|}$

Y(4S)
 or Y(10580) $I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 10.5794 \pm 0.0012$ GeV
 Y(4S)
 ?
 3 $\frac{0|0}{|}$
 2 $\frac{|}{|}$
 1 $\frac{|}{|}$
 0 $-|+$

 $\frac{1-2|-1}{|}$

Y(10860) $I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 10.865 \pm 0.008$ GeV (S = 1.1)
 Y(10860)
 ?
 3 $\frac{0|0}{|}$
 2 $\frac{|}{|}$
 1 $\frac{|}{|}$
 0 $-0|0+$

 $\frac{1-2|-1}{|}$

APP. B: STRUCTURE OF KNOWN PARTICLES 476

Y (11020) $I^G(J^{PC}) = 0^-(1^{--})$
 Mass $m = 11.019 \pm 0.008$ GeV
 Y (11020)
 ?
 3 $\frac{0|0}{|}$
 2 $\frac{|}{|}$
 1 $\frac{|}{|}$
 0 $\frac{|}{|}$

$\frac{1|1}{|}$

N BARYONS
 (S = 0, I = 1/2)

p $I(J^P) = 1/2(1/2^+)$
 Mass $m = 938.27203 \pm 0.00008$ MeV
 p
 ?
 2 $\frac{|}{|}$
 1 $\frac{|}{|}$
 0 $\frac{|no}{|}$

$\frac{1-1|1/2}{|}$

n $I(J^P) = 1/2(1/2^+)$
 Mass $m = 939.56536 \pm 0.00008$ MeV
 n
 933.948 3545 MeV
 2 $\frac{|}{|}$
 1 $\frac{|}{|}$
 0 $\frac{|n}{|}$

$\frac{-1|-1/2}{|}$

APP. B: STRUCTURE OF KNOWN PARTICLES 477

N(1440) P₁₁ I(J^P) = ½(½⁺)

Breit-Wigner mass = 1420 to 1470 (≈ 1440) MeV

$$\begin{array}{r}
 \text{N (1440) P}_{11} \\
 ? \\
 2 \quad | \\
 1 \quad | \circ \\
 0 \quad \circ | \text{no} \\
 \hline
 \frac{1-1}{1} | \frac{1}{2} \\
 |
 \end{array}$$

N(1520) D₁₃ I(J^P) = ½(3/2⁻)

Breit-Wigner mass = 1515 to 1525 (≈ 1520) MeV

$$\begin{array}{r}
 \text{N (1520) D}_{13} \\
 ? \\
 2 \quad | \\
 1 \quad | \circ \\
 0 \quad \circ | \text{no} \\
 \hline
 \frac{2-1}{1} | \frac{1}{2} \\
 |
 \end{array}$$

N(1535) S₁₁ I(J^P) = ½(½⁻)

Breit-Wigner mass = 1525 to 1545 (≈ 1535) MeV

$$\begin{array}{r}
 \text{N (1535) S}_{11} \\
 ? \\
 2 \quad | \\
 1 \quad | \circ \\
 0 \quad +\circ | \text{no}+ \\
 \hline
 \frac{1-1}{1} | \frac{1}{2} \\
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 478

$$\frac{1-2 | \frac{1}{2}}{|}$$

N(1650) S₁₁ I(J^P) = ½(½⁻)

Breit-Wigner mass = 1645 to 1670 (≈ 1655) MeV

$$\begin{array}{c} \text{N(1650) S}_{11} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad | \text{n} \\ \hline \frac{1-1 | \frac{1}{2}}{|} \end{array}$$

N(1675) D₁₅ I(J^P) = ½(5/2⁻)

Breit-Wigner mass = 1670 to 1680 (≈ 1675) MeV

$$\begin{array}{c} \text{N(1675) D}_{15} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad \circ | \text{no} \\ \hline \frac{2 | 2\frac{1}{2}}{|} \end{array}$$

N(1680) F₁₅ I(J^P) = ½(5/2⁺)

Breit-Wigner mass = 1680 to 1690 (≈ 1685) MeV

$$\begin{array}{c} \text{N(1680) F}_{15} \\ ? \\ 2 \quad | \\ 1 \quad + | + \\ 0 \quad + | \text{no} + \\ \hline \frac{3-3 | 2\frac{1}{2}}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 479

N(1700) D₁₃ I(J^P) = ½(3/2⁻)

Breit-Wigner mass = 1650 to 1750 (≈ 1700) MeV

$$\begin{array}{r}
 \text{N (1700) D}_{13} \\
 ? \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{|}{| \text{no}} \\
 \\
 \frac{1 | 1\frac{1}{2}}{|}
 \end{array}$$

N(1710) P₁₁ I(J^P) = ½(½⁺)

Breit-Wigner mass = 1680 to 1740 (≈ 1710) MeV

$$\begin{array}{r}
 \text{N (1710) P}_{11} \\
 ? \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{|}{| \text{o}} \\
 0 \quad \frac{|}{\text{o} | \text{no}} \\
 \\
 \frac{1-1 | \frac{1}{2}}{|}
 \end{array}$$

N(1720) P₁₃ I(J^P) = ½(3/2⁺)

Breit-Wigner mass = 1700 to 1750 (≈ 1720) MeV

$$\begin{array}{r}
 \text{N (1720) P}_{13} \\
 ? \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{|}{| \text{o}} \\
 0 \quad \frac{|}{+ | \text{n}^+} \\
 \\
 \frac{1-1 | 1\frac{1}{2}}{|}
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 480

$N(2190) G_{17} \quad I(J^P) = \frac{1}{2}(7/2^-)$

Breit-Wigner mass = 2100 to 2200 (≈ 2190) MeV

$$\begin{array}{r}
 N(2190) G_{17} \\
 ? \\
 \frac{2}{|} \\
 \frac{1}{|} \\
 \frac{0}{+|no+} \\
 \\
 \frac{2}{|} 3\frac{1}{2} \\
 |
 \end{array}$$

$N(2220) H_{19} \quad I(J^P) = \frac{1}{2}(9/2^+)$

Breit-Wigner mass = 2200 to 2300 (≈ 2250) MeV

$$\begin{array}{r}
 N(2220) H_{19} \\
 ? \\
 \frac{3}{-|} \\
 \frac{2}{-|} \\
 \frac{1}{+|o+} \\
 \frac{0}{+o|no+} \\
 \\
 \frac{2}{|} 4\frac{1}{2} \\
 |
 \end{array}$$

$N(2250) G_{19} \quad I(J^P) = \frac{1}{2}(9/2^-)$

Breit-Wigner mass = 2200 to 2350 (≈ 2275) MeV

$$\begin{array}{r}
 N(2250) G_{19} \\
 ? \\
 \frac{2}{|} \\
 \frac{1}{|o} \\
 \frac{0}{+o|no+} \\
 \\
 \frac{3}{|} 4\frac{1}{2} \\
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 481

$N(2600) I_{1,11} \quad I(J^P) = \frac{1}{2}(11/2^-)$
 Breit-Wigner mass = 2550 to 2750 (≈ 2600) MeV

	$N(2600) I_{1,11}$
	?
2	
1	+ +
0	+ no+

	$3 5\frac{1}{2}$

Δ BARYONS
 (S = 0, I = 3/2)

$\Delta(1232) P_{33} \quad I(J^P) = 3/2(3/2^+)$
 Breit-Wigner mass (mixed charges) = 1231 to 1233 (≈ 1232) MeV

	$\Delta(1232) P_{33}$
	?
2	
1	o
0	no

	$1 1\frac{1}{2}$

$\Delta(1600) P_{33} \quad I(J^P) = 3/2(3/2^+)$
 Breit-Wigner mass = 1550 to 1700 (≈ 1600) MeV

	$\Delta(1600) P_{33}$
	?
2	0
1	o
0	+ o no+

	$2-2 1\frac{1}{2}$

APP. B: STRUCTURE OF KNOWN PARTICLES 482

$$\Delta(1620) S_{31} \quad I(J^P) = 3/2(1/2^-)$$

Breit-Wigner mass = 1600 to 1660 (≈ 1630) MeV

$$\begin{array}{r} \Delta(1620) S_{31} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad | \text{no} \\ \hline 1-1 | 1/2 \\ | \end{array}$$

$$\Delta(1700) D_{33} \quad I(J^P) = 3/2(3/2^-)$$

Breit-Wigner mass = 1670 to 1750 (≈ 1700) MeV

$$\begin{array}{r} \Delta(1700) D_{33} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad | \text{no} \\ \hline 2-1 | 1 1/2 \\ | \end{array}$$

$$\Delta(1905) F_{35} \quad I(J^P) = 3/2(5/2^+)$$

Breit-Wigner mass = 1865 to 1915 (≈ 1890) MeV

$$\begin{array}{r} \Delta(1905) F_{35} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad | \text{no} \\ \hline 2 | 2 1/2 \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 483

$$\Delta(1910) P_{31} \quad I(J^P) = 3/2(1/2^+)$$

Breit-Wigner mass = 1870 to 1920 (≈ 1910) MeV

$$\begin{array}{r} \Delta(1910) P_{31} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{|o}{|} \\ 0 \quad \frac{|no}{|} \\ \\ \hline 1-1 | 1\frac{1}{2} \\ | \end{array}$$

$$\Delta(1920) P_{33} \quad I(J^P) = 3/2(3/2^+)$$

Breit-Wigner mass = 1900 to 1970 (≈ 1920) MeV

$$\begin{array}{r} \Delta(1920) P_{33} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{|o}{|} \\ 0 \quad \frac{+|no+}{|} \\ \\ \hline 2-2 | 1\frac{1}{2} \\ | \end{array}$$

$$\Delta(1930) D_{35} \quad I(J^P) = 3/2(5/2^-)$$

Breit-Wigner mass = 1900 to 2020 (≈ 1960) MeV

$$\begin{array}{r} \Delta(1930) D_{35} \\ ? \\ 2 \quad \frac{|o}{|} \\ 1 \quad \frac{|o}{|} \\ 0 \quad \frac{o|no}{|} \\ \\ \hline 3-1 | 2\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 484

$$\Delta(1950) F_{37} \quad I(J^P) = 3/2(7/2^+)$$

Breit-Wigner mass = 1915 to 1950 (≈ 1930) MeV

$$\begin{array}{r} \Delta(1950) F_{37} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad | \text{no} \\ \\ 3 \quad | \quad 3\frac{1}{2} \\ | \end{array}$$

$$\Delta(2420) H_{3,11} \quad I(J^P) = 3/2(11/2^+)$$

Breit-Wigner mass = 2300 to 2500 (≈ 2420) MeV

$$\begin{array}{r} \Delta(2420) H_{3,11} \\ ? \\ 2 \quad | \\ 1 \quad | \circ \\ 0 \quad + | \text{no} + \\ \\ 4 \quad | \quad 5\frac{1}{2} \\ | \end{array}$$

Λ BARYONS
(S = -1, I = 0)

$$\Lambda \quad I(J^P) = 0(\frac{1}{2}^+)$$

Mass m = 1115.683 \pm 0.006 MeV

$$\begin{array}{r} \Lambda \\ ? \\ 2 \quad | \\ 1 \quad | \text{n} \\ 0 \quad | \\ \\ -1 \quad | \quad -\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 485

$$\Lambda(1405) S_{01} \quad I(J^P) = 0(1/2^-)$$

$$\text{Mass } m = 1406 \pm 4 \text{ MeV}$$

$$\begin{array}{c} \Lambda(1405) S_{01} \\ ? \\ 2 \quad | \\ 1 \quad \frac{|n}{|} \\ 0 \quad \frac{|\circ}{|} \\ \\ \frac{1-2 \quad | \quad -1\frac{1}{2}}{|} \end{array}$$

$$\Lambda(1520) D_{03} \quad I(J^P) = 0(3/2^-)$$

$$\text{Mass } m = 1519.5 \pm 1.0 \text{ MeV}$$

$$\begin{array}{c} \Lambda(1520) D_{03} \\ ? \\ 2 \quad | \\ 1 \quad \frac{|\circ|n}{|} \\ 0 \quad \frac{|\circ}{|} \\ \\ \frac{-2 \quad | \quad -1\frac{1}{2}}{|} \end{array}$$

$$\Lambda(1600) P_{01} \quad I(J^P) = 0(1/2^+)$$

$$\text{Mass } m = 1560 \text{ to } 1700 (\approx 1600) \text{ MeV}$$

$$\begin{array}{c} \Lambda(1600) P_{01} \\ ? \\ 2 \quad | \\ 1 \quad \frac{|\circ|n}{|} \\ 0 \quad \frac{|\circ}{|} \\ \\ \frac{1-2 \quad | \quad -1\frac{1}{2}}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 486

$$\Lambda(1670) S_{01} \quad I(J^P) = 0(1/2^-)$$

Mass $m = 1660$ to 1680 (≈ 1670) MeV

$$\begin{array}{c} \Lambda(1670) S_{01} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{0|n}{|} \\ 0 \quad \frac{+|0+}{|} \\ \\ \frac{1-2|1\frac{1}{2}}{|} \end{array}$$

$$\Lambda(1690) D_{03} \quad I(J^P) = 0(3/2^-)$$

Mass $m = 1685$ to 1695 (≈ 1690) MeV

$$\begin{array}{c} \Lambda(1690) D_{03} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{0|no}{|} \\ 0 \quad \frac{0|0}{|} \\ \\ \frac{2-1|1\frac{1}{2}}{|} \end{array}$$

$$\Lambda(1800) S_{01} \quad I(J^P) = 0(1/2^-)$$

Mass $m = 1720$ to 1850 (≈ 1800) MeV

$$\begin{array}{c} \Lambda(1800) S_{01} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{0|n}{|} \\ 0 \quad \frac{|}{|} \\ \\ \frac{1-1|1\frac{1}{2}}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 487

$$\Lambda(1810) P_{01} \quad I(J^P) = 0(1/2^+)$$

$$\text{Mass } m = 1750 \text{ to } 1850 (\approx 1810) \text{ MeV}$$

$$\begin{array}{c} \Lambda(1810) P_{01} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{o | n o}{|} \\ 0 \quad \frac{o | o}{|} \\ \\ \hline 2-2 | 2\frac{1}{2} \\ | \end{array}$$

$$\Lambda(1820) F_{05} \quad I(J^P) = 0(5/2^+)$$

$$\text{Mass } m = 1815 \text{ to } 1825 (\approx 1820) \text{ MeV}$$

$$\begin{array}{c} \Lambda(1820) F_{05} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{+o | n+}{|} \\ 0 \quad \frac{+ | o+}{|} \\ \\ \hline 2-2 | 2\frac{1}{2} \end{array}$$

$$\Lambda(1830) D_{05} \quad I(J^P) = 0(5/2^-)$$

$$\text{Mass } m = 1810 \text{ to } 1830 (\approx 1830) \text{ MeV}$$

$$\begin{array}{c} \Lambda(1830) D_{05} \\ ? \\ 2 \quad \frac{|}{|} \\ 1 \quad \frac{o | n}{|} \\ 0 \quad \frac{|}{|} \\ \\ \hline 2 | 2\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 488

$$\Lambda(1890) P_{03} \quad I(J^P) = 0(3/2^+)$$

Mass $m = 1850$ to 1910 (≈ 1890) MeV

$$\begin{array}{c} \Lambda(1890) P_{03} \\ ? \\ 2 \quad | \\ 1 \quad \frac{o | n}{-} \\ 0 \quad + | o+ \\ \hline 2-2 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

$$\Lambda(2100) G_{07} \quad I(J^P) = 0(7/2^-)$$

Mass $m = 2090$ to 2110 (≈ 2100) MeV

$$\begin{array}{c} \Lambda(2100) G_{07} \\ ? \\ 2 \quad | \\ 1 \quad \frac{o | n}{-} \\ 0 \quad - | o- \\ \hline -3 \quad | \quad -3\frac{1}{2} \\ | \end{array}$$

$$\Lambda(2110) F_{05} \quad I(J^P) = 0(5/2^+)$$

Mass $m = 2090$ to 2140 (≈ 2110) MeV

$$\begin{array}{c} \Lambda(2110) F_{05} \\ ? \\ 2 \quad | \\ 1 \quad \frac{+o | n+}{-} \\ 0 \quad + | o+ \\ \hline 2-2 \quad | \quad 2\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 489

$\Lambda(2350) H_{09} \quad I(J^P) = 0(9/2^+)$

Mass $m = 2340$ to 2370 (≈ 2350) MeV

$\Lambda(2350) H_{09}$

	?
3	
2	
1	+o n+
0	+ o+

$\frac{2-1}{1} 4\frac{1}{2}$

Σ BARYONS
($S = -1, I = 1$)

$\Sigma^+ \quad I(J^P) = 1(\frac{1}{2}^+)$

Mass $m = 1189.37 \pm 0.07$ MeV ($S = 2.2$)

	Σ^+
	?
2	
1	n
0	o

$\frac{1-1}{1} 1\frac{1}{2}$

$\Sigma^0 \quad I(J^P) = 1(\frac{1}{2}^+)$
Mass $m = 1192.642 \pm 0.024$ MeV

	Σ^0
	?
2	
1	n
0	o o

$\frac{1-1}{1} 1\frac{1}{2}$

APP. B: STRUCTURE OF KNOWN PARTICLES 490

$$\Sigma^- \quad I(J^P) = 1(1/2^+)$$

$$\text{Mass } m = 1197.449 \pm 0.030 \text{ MeV} \quad (S = 1.2)$$

$$\begin{array}{c} \Sigma^- \\ ? \\ 2 \quad | \\ 1 \quad |n \\ 0 \quad |o| \\ \hline 1-1 \quad |1\frac{1}{2} \\ | \end{array}$$

$$\Sigma(1385)^+ P_{13} \quad I(J^P) = 1(3/2^+)$$

$$\text{Mass } m = 1382.8 \pm 0.4 \text{ MeV} \quad (S = 2.0)$$

$$\begin{array}{c} \Sigma(1385)^+ P_{13} \\ ? \\ 2 \quad | \\ 1 \quad |n \\ 0 \quad +|o+ \\ \hline 1-1 \quad |1\frac{1}{2} \\ | \end{array}$$

$$\Sigma(1385)^0 P_{13} \quad I(J^P) = 1(3/2^+)$$

$$\text{Mass } m = 1383.7 \pm 1.0 \text{ MeV} \quad (S = 1.4)$$

$$\begin{array}{c} \Sigma(1385)^0 P_{13} \\ ? \\ 2 \quad | \\ 1 \quad |n \\ 0 \quad +o|o+ \\ \hline 2-2 \quad |1\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 491

$$\Sigma(1385)^- P_{13} \quad I(J^P) = 1(3/2^+)$$

$$\text{Mass } m = 1387.2 \pm 0.5 \text{ MeV} \quad (S = 2.2)$$

$$\begin{array}{c} \Sigma(1385)^- P_{13} \\ ? \\ 2 \quad | \\ 1 \quad | \text{no} \\ 0 \quad | \text{o} | \text{o}+ \\ \hline 2-2 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

$$\Sigma(1660) P_{11} \quad I(J^P) = 1(1/2^+)$$

$$\text{Mass } m = 1630 \text{ to } 1690 (\approx 1660) \text{ MeV}$$

$$\begin{array}{c} \Sigma(1660) P_{11} \\ ? \\ 2 \quad | \\ 1 \quad | \text{o} | \text{no} \\ 0 \quad | \text{o} \\ \hline 1-1 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

$$\Sigma(1670) D_{13} \quad I(J^P) = 1(3/2^-)$$

$$\text{Mass } m = 1665 \text{ to } 1685 (\approx 1670) \text{ MeV}$$

$$\begin{array}{c} \Sigma(1670) D_{13} \\ ? \\ 2 \quad | \\ 1 \quad | \text{o} | \text{no} \\ 0 \quad | \text{o} \\ \hline 2-1 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 492

$$\Sigma(1750) S_{11} \quad I(J^P) = 1(1/2)$$

Mass $m = 1730$ to 1800 (≈ 1750) MeV

$$\begin{array}{c} \Sigma(1750) S_{11} \\ ? \\ 2 \quad | \\ 1 \quad | \text{no} \\ 0 \quad | \text{o} \\ \hline 2-2 \quad | \frac{1}{2} \\ | \end{array}$$

$$\Sigma(1775) D_{15} \quad I(J^P) = 1(5/2)$$

Mass $m = 1770$ to 1780 (≈ 1775) MeV

$$\begin{array}{c} \Sigma(1775) D_{15} \\ ? \\ 2 \quad | \\ 1 \quad | \text{o} | \text{no} \\ 0 \quad | + | \text{o} + \\ \hline 2-1 \quad | 2\frac{1}{2} \\ | \end{array}$$

$$\Sigma(1915) F_{15} \quad I(J^P) = 1(5/2^+)$$

Mass $m = 1900$ to 1935 (≈ 1915) MeV

$$\begin{array}{c} \Sigma(1915) F_{15} \\ ? \\ 2 \quad | \\ 1 \quad | + \text{o} | \text{no} + \\ 0 \quad | + | \text{o} + \\ \hline 2-2 \quad | 2\frac{1}{2} \\ | \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES

$\Sigma(1940) D_{13} \quad I(J^P) = 1(3/2^-)$

Mass $m = 1900$ to 1950 (≈ 1940) MeV

	$\Sigma(1940) D_{13}$
	?
2	
1	+ n o
0	+ o +
	-3 -1½

$\Sigma(2030) F_{17} \quad I(J^P) = 1(7/2^+)$

Mass $m = 2025$ to 2040 (≈ 2030) MeV

	$\Sigma(2030) F_{17}$
	?
2	+ +
1	+ o n o +
0	+ o +
	3-3 3½

$\Sigma(2250) \quad I(J^P) = 1(?^?)$

Mass $m = 2210$ to 2280 (≈ 2250) MeV

	$\Sigma(2250)$	
	?	
2		
1	+ n +	
0	+ o +	
	3 5½	Unknown

APP. B: STRUCTURE OF KNOWN PARTICLES

Ξ BARYONS (S = -2, I = 1/2)

Ξ⁰ I(J^P) = 1/2(1/2⁺) P is not yet measured; + is the quark model prediction.
 Mass m = 1314.86 ± 0.20 MeV

$$\begin{array}{c}
 \Xi^0 \\
 ? \\
 2 \quad \frac{|n}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{|}{|} \\
 \\
 \frac{-1 \quad | \quad -\frac{1}{2}}{|}
 \end{array}$$

Ξ⁻ I(J^P) = 1/2(1/2⁺) P is not yet measured; + is the quark model prediction.
 Mass m = 1321.71 ± 0.07 MeV

$$\begin{array}{c}
 \Xi^- \\
 ? \\
 2 \quad \frac{|n}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{o|}{|} \\
 \\
 \frac{1-1 \quad | \quad \frac{1}{2}}{|}
 \end{array}$$

Ξ(1530)⁰ P₁₃ I(J^P) = 1/2(3/2⁺)

Mass m = 1531.80 ± 0.32 MeV (S = 1.3)

$$\begin{array}{c}
 \Xi(1530)^0 P_{13} \\
 ? \\
 2 \quad \frac{|n}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{+o|o+}{|} \\
 \\
 \frac{2-2 \quad | \quad 1\frac{1}{2}}{|}
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES

$$\Xi(1530)^- P_{13} \quad I(J^P) = \frac{1}{2}(3/2^+)$$

$$\text{Mass } m = 1535.0 \pm 0.6 \text{ MeV}$$

$$\begin{array}{c} \Xi(1530)^- P_{13} \\ ? \\ 2 \quad \frac{|n}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{+o|+}{|} \\ \\ \frac{1-1|1\frac{1}{2}}{|} \end{array}$$

$$\Xi(1690) \quad I(J^P) = \frac{1}{2}(?)^?$$

$$\text{Mass } m = 1690 \pm 10 \text{ MeV}$$

$$\begin{array}{c} \Xi(1690) \\ ? \\ 2 \quad \frac{|n}{|} \\ 1 \quad \frac{o|}{|} \\ 0 \quad \frac{|o}{|} \\ \\ \frac{1-1|1\frac{1}{2}}{|} \quad \text{Unknown} \end{array}$$

$$\Xi(1820) D_{13} \quad I(J^P) = \frac{1}{2}(3/2^-)$$

$$\text{Mass } m = 1823 \pm 5 \text{ MeV}$$

$$\begin{array}{c} \Xi(1820) D_{13} \\ ? \\ 2 \quad \frac{|n}{|} \\ 1 \quad \frac{o|}{|} \\ 0 \quad \frac{|o}{|} \\ \\ \frac{2-1|1\frac{1}{2}}{|} \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES

$\Xi(1950) \quad I(J^P) = \frac{1}{2}(?^?)$

Mass $m = 1950 \pm 15$ MeV

	$\Xi(1950)$	
	?	
2	$\frac{ n}{ }$	
1	$\frac{o }{ }$	
0	$\frac{ }{ }$	
	$\frac{1 1\frac{1}{2}}{ }$	Unknown

$\Xi(2030) \quad I(J^P) = \frac{1}{2}(\geq 5/2^?)$

Mass $m = 2025 \pm 5$ MeV

	$\Xi(2030)$	
	?	
2	$\frac{ n}{ }$	
1	$\frac{o }{ }$	
0	$\frac{ o}{ }$	
	$\frac{2 2\frac{1}{2}}{ }$	Unknown

Ω BARYONS ($S = -3, I = 0$)

$\Omega^- \quad I(J^P) = 0(3/2^+) \quad J^P$ is not yet measured; $3/2^+$ is the quark model prediction.

Mass $m = 1672.45 \pm 0.29$ MeV

	Ω^-	
	?	
2	$\frac{ n}{ }$	
1	$\frac{o }{ }$	
0	$\frac{+ +}{ }$	
	$\frac{1-1 1\frac{1}{2}}{ }$	

$\Omega(2250)^-$	$I(J^P) = 0(?)^?$	
Mass $m = 2252 \pm 9$ MeV		
	$\Omega(2250)^-$	
	?	
2	n	
1	o	
0	o o	
	<u>2 2^{1/2}</u>	Unknown

CHARMED BARYONS
(C = + 1)

Λ_c^+ $I(J^P) = 0(1/2^+)$ J not confirmed; 1/2 is the quark model prediction.

Mass $m = 2286.46 \pm 0.14$ MeV

	Λ_c^+	
	?	
2	n o	
1		
0		
	<u>1-1 1/2</u>	

$\Lambda_c(2595)^+$ $I(J^P) = 0(1/2^-)$ The spin-parity follows from the fact that $\Sigma_c(2455)\pi$ decays, with little available space, are dominant.

Mass $m = 2595.4 \pm 0.6$ MeV

	$\Lambda_c(2595)^+$	
	?	
2	n o	
1		
0	o o	
	<u>1-1 1/2</u>	

APP. B: STRUCTURE OF KNOWN PARTICLES 498

$\Lambda_c(2625)^+$ $I(J^P) = 0(3/2^-)$ J^P is expected to be $3/2^-$.

Mass $m = 2628.1 \pm 0.6$ MeV ($S = 1.5$)

$$\begin{array}{r} \Lambda_c(2625)^+ \\ ? \\ 2 \quad \frac{|no}{|} \\ 1 \quad \frac{|}{|} \\ 0 \quad \frac{o|o}{|} \\ \hline 2-1 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

$\Lambda_c(2880)^+$ $I(J^P) = 0(5/2^+)$ There is some good evidence that indeed $J^P = 5/2^+$.

Mass $m = 2881.53 \pm 0.35$ MeV

$$\begin{array}{r} \Lambda_c(2880)^+ \\ ? \\ 2 \quad \frac{|no}{|} \\ 1 \quad \frac{+|+}{|} \\ 0 \quad \frac{+o|o+}{|} \\ \hline 2-2 \quad | \quad 2\frac{1}{2} \\ | \end{array}$$

$\Lambda_c(2940)^+$ $I(J^P) = 0(?^?)$

Mass $m = 2939.3^{+1.4}_{-1.5}$ MeV

$$\begin{array}{r} \Lambda_c(2940)^+ \\ ? \\ 2 \quad \frac{|no}{|} \\ 1 \quad \frac{+|+}{|} \\ 0 \quad \frac{+o|o+}{|} \\ \hline 3-1 \quad | \quad 4\frac{1}{2} \\ | \end{array} \quad \text{Unknown}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 499

$\Sigma_c(2455)^{++}$ $I(J^P) = 1(1/2^+)$ J^P not confirmed; $1/2^+$ is the quark model prediction.
 Mass $m = 2454.02 \pm 0.18$ MeV

	$\Sigma_c(2455)^{++}$
	?
2	$\frac{ no}{ }$
1	$\frac{ }{ }$
0	$\frac{ o}{ }$
	$\frac{1-1 1/2}{ }$

$\Sigma_c(2455)^+$ $I(J^P) = 1(1/2^+)$ J^P not confirmed; $1/2^+$ is the quark model prediction.
 Mass $m = 2452.9 \pm 0.4$ MeV

	$\Sigma_c(2455)^+$
	?
2	$\frac{ no}{ }$
1	$\frac{ }{ }$
0	$\frac{o }{ }$
	$\frac{1-1 1/2}{ }$

$\Sigma_c(2455)^0$ $I(J^P) = 1(1/2^+)$ J^P not confirmed; $1/2^+$ is the quark model prediction.
 Mass $m = 2453.76 \pm 0.18$ MeV

	$\Sigma_c(2455)^0$
	?
2	$\frac{ no}{ }$
1	$\frac{ }{ }$
0	$\frac{o }{ }$
	$\frac{1-1 1/2}{ }$

APP. B: STRUCTURE OF KNOWN PARTICLES 500

$$\Sigma_c(2520)^{++} \quad I(J^P) = 1(3/2^+)$$

$$\text{Mass } m = 2518.4 \pm 0.6 \text{ MeV}$$

$$\begin{array}{c} \Sigma_c(2520)^{++} \\ ? \\ 2 \quad | \text{no} \\ 1 \quad | \\ 0 \quad + | \text{o} + \\ \hline 2-2 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

$$\Sigma_c(2520)^0 \quad I(J^P) = 1(3/2^+)$$

$$\text{Mass } m = 2518.0 \pm 0.5 \text{ MeV}$$

$$\begin{array}{c} \Sigma_c(2520)^0 \\ ? \\ 2 \quad | \text{no} \\ 1 \quad | \\ 0 \quad + \text{o} | + \\ \hline 2-2 \quad | \quad 1\frac{1}{2} \\ | \end{array}$$

$$\Sigma_c(2800) \quad I(J^P) = 1(?) \quad \text{Unknown structures.}$$

$$\Sigma_c(2800)^{++} \text{ mass } m = 2801_{-6}^{+4} \text{ MeV}$$

$$\Sigma_c(2800)^+ \text{ mass } m = 2792_{-5}^{+14} \text{ MeV}$$

$$\Sigma_c(2800)^0 \text{ mass } m = 2802_{-7}^{+4} \text{ MeV}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 501

Ξ_c^+ $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ $I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2467.9 \pm 0.4$ MeV

	Ξ_c^+
	?
2	$\frac{\quad}{\quad} n o$
1	$\frac{o \quad}{\quad}$
0	$\quad o$
	$\frac{1-1 \frac{1}{2}}{\quad}$

Ξ_c^0 $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ $I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2471.0 \pm 0.4$ MeV

	Ξ_c^0
	?
2	$\frac{\quad}{\quad} n o$
1	$\frac{o \quad}{\quad}$
0	$\quad o$
	$\frac{2-2 \frac{1}{2}}{\quad}$

$\Xi_c^{'+}$ $I(J^P) = \frac{1}{2}(\frac{1}{2}^+)$ $I(J^P)$ not confirmed; $\frac{1}{2}(\frac{1}{2}^+)$ is the quark model prediction.

Mass $m = 2575.7 \pm 3.1$ MeV

	Ξ_c^0
	?
2	$\frac{o \quad n o}{\quad}$
1	$\frac{o \quad o}{\quad}$
0	$\quad o$
	$\frac{2-2 \frac{1}{2}}{\quad}$

APP. B: STRUCTURE OF KNOWN PARTICLES 502

$\Xi_c^{\prime 0}$ $I(J^P) = 1/2(1/2^+)$ $I(J^P)$ not confirmed; $1/2(1/2^+)$ is the quark model prediction.
 Mass $m = 2578.0 \pm 2.9$ MeV

	Ξ_c^0
	?
2	$\frac{0 no}{\quad}$
1	$\frac{0 0}{\quad}$
0	$\frac{0 0}{\quad}$
	$\frac{2-2}{\quad} 1/2$

$\Xi_c(2645)^+$ $I(J^P) = 1/2(3/2^+)$
 Mass $m = 2646.6 \pm 1.4$ MeV (S = 1.6)

	$\Xi_c(2645)^+$
	?
2	$\frac{ no}{\quad}$
1	$\frac{0 }{\quad}$
0	$\frac{+ 0+}{\quad}$
	$\frac{2-2}{\quad} 1/2$

$\Xi_c(2645)^0$ $I(J^P) = 1/2(3/2^+)$
 Mass $m = 2646.1 \pm 1.2$ MeV

	$\Xi_c(2645)^0$
	?
2	$\frac{ no}{\quad}$
1	$\frac{0 }{\quad}$
0	$\frac{+ +}{\quad}$
	$\frac{2-2}{\quad} 1/2$

APP. B: STRUCTURE OF KNOWN PARTICLES 503

$$\Xi_c(2790)^+ \quad I(J^P)=1/2(1/2^-)$$

J^P has not been measured; $1/2^-$ is the quark model prediction.
 Mass $m = 2789.2 \pm 3.2$ MeV

	$\Xi_c(2790)^0$
	?
2	$\frac{ no\rangle}{\quad}$
1	$\frac{o }{\quad}$
0	$+ o\rangle$

$\frac{1-2}{1} | 1/2^-$

$$\Xi_c(2790)^0 \quad I(J^P)=1/2(1/2^-)$$

J^P has not been measured; $1/2^-$ is the quark model prediction.
 Mass $m = 2791.9 \pm 3.3$ MeV

	$\Xi_c(2790)^0$
	?
2	$\frac{ no\rangle}{\quad}$
1	$\frac{o }{\quad}$
0	$+o o\rangle$

$\frac{1-2}{1} | 1/2^-$

$$\Xi_c(2815)^+ \quad I(J^P)=1/2(3/2^-)$$

J^P has not been measured; $1/2^-$ is the quark model prediction.
 Mass $m = 2816.5 \pm 1.2$ MeV

	$\Xi_c(2815)^0$
	?
2	$\frac{ no\rangle}{\quad}$
1	$\frac{o }{\quad}$
0	$o o\rangle$

$\frac{2-1}{1} | 1 1/2^-$

APP. B: STRUCTURE OF KNOWN PARTICLES 504

$\Xi_c(2815)^0$ $I(J^P) = 1/2(3/2^-)$
 J^P has not been measured; $1/2^-$ is the quark model prediction.
 Mass $m = 2818.2 \pm 1.2$ MeV

	$\Xi_c(2815)^0$
	?
2	no
1	o
0	o o
	<hr style="width: 50%; margin: 0 auto;"/>
	$2-1 1\frac{1}{2}$

$\Xi_c(2980)$ $I(J^P) = 1/2(?)^?$ Unknown structures.

$\Xi_c(2980)^+$ $m = 2974 \pm 5$ MeV (S = 2.3)

$\Xi_c(2980)^0$ $m = 2974 \pm 4$ MeV

$\Xi_c(3080)$ $I(J^P) = 1/2(?)^?$ Unknown structures.

$\Xi_c(3080)^+$ $m = 3077.0 \pm 0.4$ MeV

$\Xi_c(3080)^0$ $m = 3079.9 \pm 1.4$ MeV

Ω_c^0 $I(J^P) = 0(1/2^+)$ $I(J^P)$ not confirmed; $0(1/2^+)$ is the quark model prediction.

Mass $m = 2697.5 \pm 2.6$ MeV (S = 1.2)

	Ω_c^0
	?
2	no
1	o
0	o o
	<hr style="width: 50%; margin: 0 auto;"/>
	$2-2 \frac{1}{2}$

APP. B: STRUCTURE OF KNOWN PARTICLES 505

$\Omega_c(2770)^0$ $I(J^P) = 0(3/2^+)$ $I(J^P)$ not confirmed; $0(1/2^+)$ is the quark model prediction.

Mass $m = 2768.3 \pm 3.0$ MeV ($S = 1.2$)

$$\begin{array}{c}
 \Omega_c^0 \\
 ? \\
 2 \quad \frac{|n\circ|}{|} \\
 1 \quad \frac{\circ|}{|} \\
 0 \quad \frac{+\circ| \circ+}{|} \\
 \\
 \hline
 2-2 \quad | \quad 1\frac{1}{2} \\
 |
 \end{array}$$

BOTTOM BARYONS
($B = -1$)

Λ_b^0 $I(J^P) = 0(1/2^+)$ $I(J^P)$ not yet measured; $0(1/2^+)$ is the quark model prediction.

Mass $m = 5620.2 \pm 1.6$ MeV

$$\begin{array}{c}
 \Lambda_b^0 \\
 ? \\
 3 \quad \frac{|n}{|} \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{|}{|} \\
 \\
 \hline
 -1 \quad | \quad -\frac{1}{2} \\
 |
 \end{array}$$

Σ_b^+ $I(J^P) = 1(1/2^+)$ I, J, P need confirmation.

Mass $m = 5807.8 \pm 2.7$ MeV

$$\begin{array}{c}
 \Sigma_b^+ \\
 ? \\
 3 \quad \frac{|n}{|} \\
 2 \quad \frac{|}{|} \\
 1 \quad \frac{|}{|} \\
 0 \quad \frac{| \circ}{|} \\
 \\
 \hline
 1-1 \quad | \quad \frac{1}{2} \\
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 506

Σ_b^- $I(J^P) = 1(1/2^+)$ I, J, P need confirmation.
 Mass $m = 5815.2 \pm 2.0$ MeV

	Σ_b^-
	?
3	n
2	
1	
0	o
	<hr style="width: 50%; margin: 0 auto;"/>
	1-1 1/2

Σ_b^{*+} $I(J^P) = 1(3/2^+)$ I, J, P need confirmation.
 Mass $m = 5829.0 \pm 3.4$ MeV

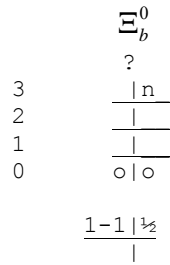
	Σ_b^{*+}
	?
3	n
2	
1	
0	+ o+
	<hr style="width: 50%; margin: 0 auto;"/>
	1-1 1/2

Σ_b^{*-} $I(J^P) = 1(3/2^+)$ I, J, P need confirmation.
 Mass $m = 5836.4 \pm 2.8$ MeV

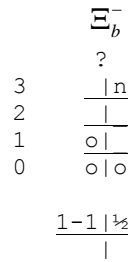
	Σ_b^{*-}
	?
3	n
2	
1	
0	+o +
	<hr style="width: 50%; margin: 0 auto;"/>
	1-1 1/2

APP. B: STRUCTURE OF KNOWN PARTICLES 507

Ξ_b^0 $I(J^P) = 1/2(1/2^+)$ I, J, P need confirmation.
 Mass $m = 5792.4 \pm 3.0$ MeV

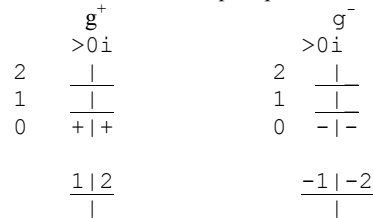


Ξ_b^- $I(J^P) = 1/2(1/2^+)$ I, J, P need confirmation.
 Mass $m = 5792.4 \pm 3.0$ MeV



GRAVITONS

g^\pm $I(J) = 0(2)$
 Mass m undetermined; expect positive imaginary component.



Higher energy state orbiting particle pairs can also compose g^\pm gravitons.

APP. B: STRUCTURE OF KNOWN PARTICLES 508

g^{0+} $I(J) = 0(2)$
 Mass m undetermined; expect positive imaginary component.

$$\begin{array}{c}
 g^{0+} \\
 >0i \\
 2 \quad | \\
 \hline
 1 \quad | \\
 \hline
 0 \quad | \quad | \quad | \quad | \\
 +o \quad | \quad o+ \\
 \\
 \hline
 -3 \quad | \quad -2 \\
 |
 \end{array}$$

A negative + echon orbits a positive o echon with -1 orbital spin, forming a neutrino. A positive + echon orbits a negative o echon with -1 orbital spin, forming an anti-neutrino. The neutrino and anti- neutrino orbit each other with an additional -1 orbital spin. The result is a g^{0+} graviton with -2 spin.

g^{0-} $I(J) = 0(2)$ The spin conjugate graviton g^{0-} is also possible.

$$\begin{array}{c}
 g^{0-} \\
 >0i \\
 2 \quad | \\
 \hline
 1 \quad | \\
 \hline
 0 \quad | \quad | \quad | \quad | \\
 -o \quad | \quad o- \\
 \\
 \hline
 3 \quad | \quad 2 \\
 |
 \end{array}$$

According to chonomic decay schemes, a 1 spin graviton also exists.

g^0 $I(J) = 0(1)$
 Mass m undetermined; expect positive imaginary component.

$$\begin{array}{c}
 g^0 \\
 >0i \\
 2 \quad | \\
 \hline
 1 \quad | \\
 \hline
 0 \quad | \quad | \quad | \quad | \\
 o \quad | \quad o \\
 \\
 \hline
 1 \quad | \quad 1 \\
 |
 \end{array}$$

APP. B: STRUCTURE OF KNOWN PARTICLES 509

MAGNETONS

The magnetic moments cancel out in gravitons. Not so in magnetons. The $\omega(782)$ particle is a magneton, as are other ω particles.

$$\begin{array}{l} \omega(782) \qquad I^G(J^{PC}) = 0^-(1^-) \\ \text{Mass } m = 781.94 \pm 0.12 \text{ MeV} \quad (S = 1.5) \\ \qquad \qquad \qquad \omega(782) \\ \qquad \qquad \qquad ? \\ 2 \qquad \qquad \frac{|}{|} \\ 1 \qquad \qquad \frac{|}{|} \\ 0 \qquad \qquad -|+ \\ \\ \qquad \qquad \frac{1|1}{|} \end{array}$$
