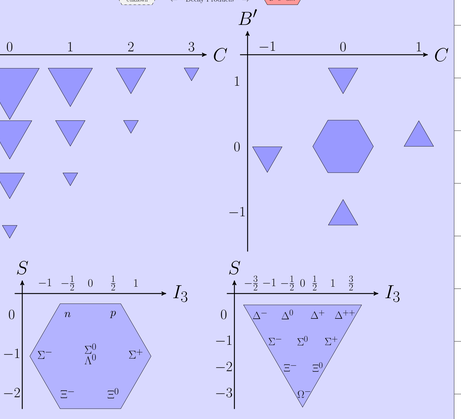
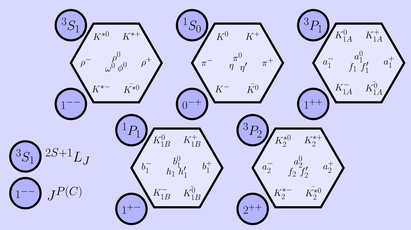
Table of Hadrons

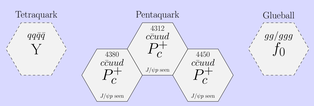
$\infty - 10^{-6} - 10^{-11} - 10^{-15} - 10^{-21} - 10^{-23} - 10^{-26} -$ Unkn



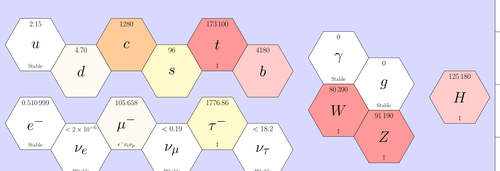
Higher Angular Momentum States



Exotic Hadrons



Standard Model



t

qqb	66.5
$\mu^+\nu_\mu b$	13.4
$e^+\nu_e b$	13.3
W^+b	9.4

τ^-

$\pi^-\pi^0\nu_\tau$	25.52
$e^-\nu_e\nu_\tau$	17.82
$\mu^-\bar{\nu}_\mu\nu_\tau$	17.39

W

Hadrons	67.41
$\tau\nu_\tau$	11.38
$e\nu_e$	10.71
$\mu\nu_\mu$	10.63

H

bb	58.4
W^+W^-	21.4
gg	9
$\tau^+\tau^-$	6.27

*Neutrino oscillations: flavor states are not mass eigenstates - See PMNS below

Flavor Mixing Matrices

$$V = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{bmatrix} \begin{bmatrix} c_{13} & 0 & s_{13}e^{i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{bmatrix} \begin{bmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$c_{ij} = \cos\theta_{ij} \quad s_{ij} = \sin\theta_{ij}$$

Cabbibo-Kobayashi-Maskawa (CKM) Matrix

$$\begin{bmatrix} |V_{ud}| & |V_{us}| & |V_{ub}| \\ |V_{cd}| & |V_{cs}| & |V_{cb}| \\ |V_{td}| & |V_{ts}| & |V_{tb}| \end{bmatrix} = \begin{bmatrix} 0.97427 & 0.22534 & 0.00351 \\ 0.22520 & 0.97344 & 0.0412 \\ 0.00867 & 0.0404 & 0.999146 \end{bmatrix}$$

$\theta_{12} = 13.04 \pm 0.05^\circ \quad \theta_{13} = 0.201 \pm 0.011^\circ \quad \theta_{23} = 2.38 \pm 0.06^\circ \quad \delta = 1.20 \pm 0.08$ rad

Pontecorvo-Maki-Nakagawa-Sakata (PMNS) Matrix

$$\begin{bmatrix} |U_{e1}| & |U_{e2}| & |U_{e3}| \\ |U_{\mu 1}| & |U_{\mu 2}| & |U_{\mu 3}| \\ |U_{\tau 1}| & |U_{\tau 2}| & |U_{\tau 3}| \end{bmatrix} = \begin{bmatrix} 0.822 & 0.549 & 0.149 \\ 0.368 & 0.523 & 0.707 \\ 0.403 & 0.593 & 0.685 \end{bmatrix}$$

$\theta_{12} = 32.62 \pm 0.77^\circ \quad \theta_{13} = 47.2 \pm 1.9^\circ \quad \theta_{23} = 8.54 \pm 0.15^\circ \quad \delta = 234 \pm 43^\circ$

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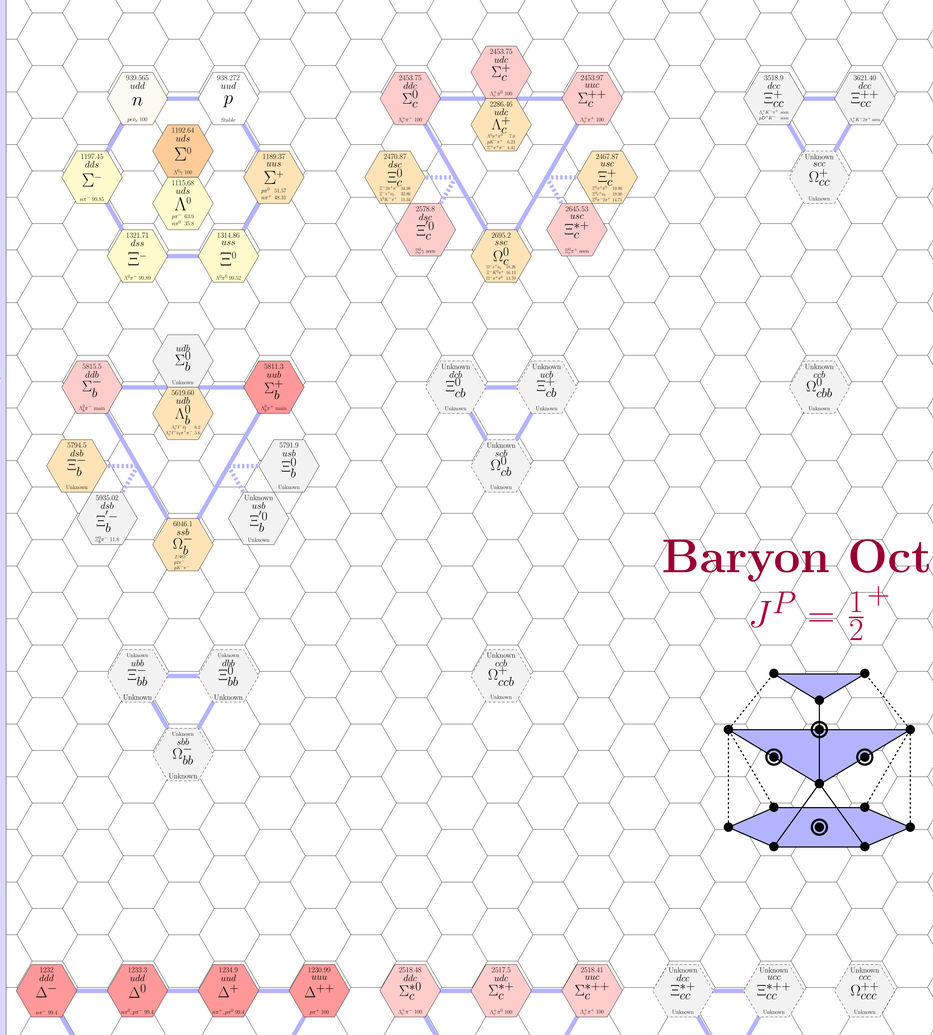
Values consistent with current publications and Particle Data Group as of September 2019.

Genessa Benton
Kitran Colwell Ph.D.
Derek DeRouen

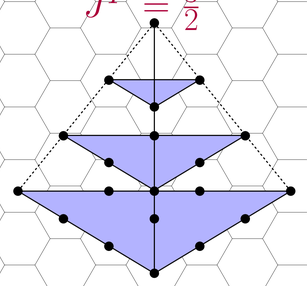
Baryon Octet

$J^P = \frac{1}{2}^+$



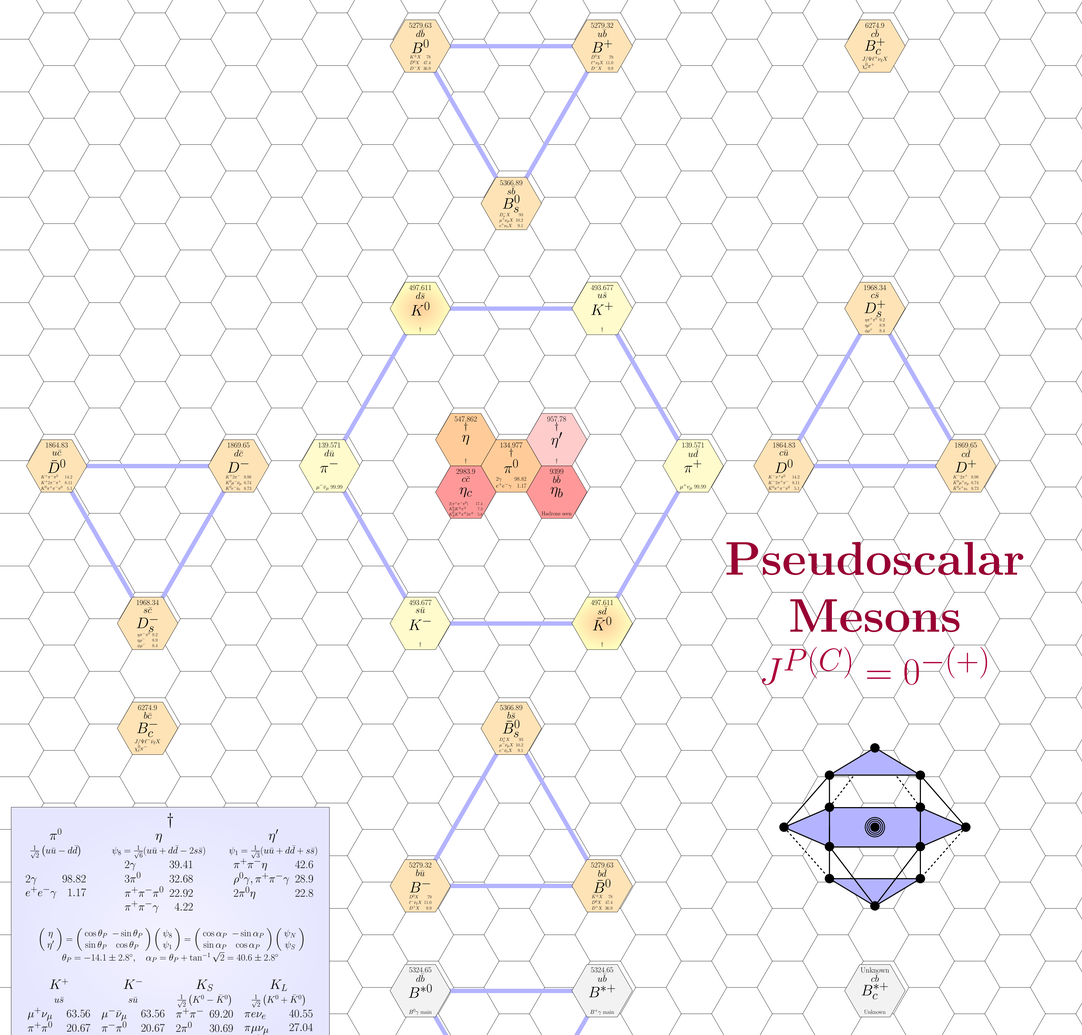
Baryon Decuplet

$J^P = \frac{3}{2}^+$



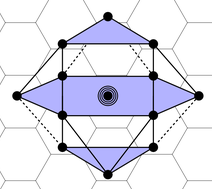
Pseudoscalar Mesons

$J^P(C) = 0^{-(+)}$



Vector Mesons

$J^{P(C)} = 1^{-(-)}$



$\dagger$

π^0		η		η'	
$\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$		$\psi_8 = \frac{1}{\sqrt{6}}(u\bar{u} + d\bar{d} - 2s\bar{s})$		$\psi_1 = \frac{1}{\sqrt{3}}(u\bar{u} + d\bar{d} + s\bar{s})$	
2γ	98.82	2γ	39.41	$\pi^+\pi^-\eta$	42.6
$e^+e^-\gamma$	1.17	$3\pi^0$	32.68	$\rho^0\gamma, \pi^+\pi^-\gamma$	28.9
		$\pi^+\pi^-\pi^0$	22.92	$2\pi^0\eta$	22.8
		$\pi^+\pi^-\gamma$	4.22		

$$\begin{pmatrix} \eta \\ \eta' \end{pmatrix} = \begin{pmatrix} \cos\theta_P & -\sin\theta_P \\ \sin\theta_P & \cos\theta_P \end{pmatrix} \begin{pmatrix} \psi_8 \\ \psi_1 \end{pmatrix} = \begin{pmatrix} \cos\alpha_P & -\sin\alpha_P \\ \sin\alpha_P & \cos\alpha_P \end{pmatrix} \begin{pmatrix} \psi_N \\ \psi_S \end{pmatrix}$$

$\theta_P = -14.1 \pm 2.8^\circ, \quad \alpha_P = \theta_P + \tan^{-1}\sqrt{2} = 40.6 \pm 2.8^\circ$

K^+ $u\bar{s}$		K^- $\bar{u}s$		K_S $\frac{1}{\sqrt{2}}(K^0 - \bar{K}^0)$		K_L $\frac{1}{\sqrt{2}}(K^0 + \bar{K}^0)$	
$\mu^+\nu_\mu$	63.56	$\mu^-\bar{\nu}_\mu$	63.56	$\pi^+\pi^-$	69.20	$\pi e\nu_e$	40.55
$\pi^+\pi^0$	20.67	$\pi^-\pi^0$	20.67	$2\pi^0$	30.69	$\pi\mu\nu_\mu$	27.04
$2\pi^+\pi^-$	5.583	$2\pi^-\pi^+$	5.583			$3\pi^0$	19.52
$\pi^0 e^+\nu_e$	5.07	$\pi^0 e^-\bar{\nu}_e$	5.07			$\pi^+\pi^-\pi^0$	12.54

$\ddagger$

ρ^0		ϕ $s\bar{s}$		ω	
$\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$		$\psi_S = s\bar{s}$		$\psi_N = \frac{1}{\sqrt{2}}(u\bar{u} + d\bar{d})$	
$\pi^+\pi^-$	100	K^+K^-	49.2	$\pi^+\pi^-\pi^0$	89.2
		$K_L^0 K_S^0$	34.0	$\pi^0\gamma$	8.40
		$\rho\pi, \pi^+\pi^-\pi^-\pi^0$	15.2		

$$\begin{pmatrix} \phi \\ \omega \end{pmatrix} = \begin{pmatrix} \cos\theta_V & -\sin\theta_V \\ \sin\theta_V & \cos\theta_V \end{pmatrix} \begin{pmatrix} \psi_8 \\ \psi_1 \end{pmatrix} = \begin{pmatrix} \cos\alpha_V & -\sin\alpha_V \\ \sin\alpha_V & \cos\alpha_V \end{pmatrix} \begin{pmatrix} \psi_N \\ \psi_S \end{pmatrix}$$

$\theta_V = 36.4^\circ, \quad \alpha_V = \theta_V + \tan^{-1}\sqrt{2} = 91.1^\circ$

J/ψ $c\bar{c}$		Υ $b\bar{b}$	
Hadrons	87.7	Hadrons	86.8
e^+e^-	5.97	$\tau^+\tau^-$	2.60
$\mu^+\mu^-$	5.96	$\mu^+\mu^-$	2.48
		e^+e^-	2.38