☞Low Mass baryons -I

Properties of low-mass baryons

Name	Symbol	Spin (parity) $J^{(p)}$	T Isospin	T_3 Isospin projection	Hyper charge	Mass [MeV]	τ Lifetime	Main decay	Branching ratio [%]
Nucleon	N p	$1/2^+$	$\frac{1}{2}$	$\frac{1}{2}$	1	938.3	∞	—	
	n	$1/2^+$	$\frac{1}{2}$	$-\frac{1}{2}$	1	939.6	15 min	$pe^-\bar{\nu}_e$	100
Hyperons									
Lambda	Λ^0	$1/2^+$	0	0	0	1116	2.6×10^{-10} s	$p\pi^-$ $n\pi^0$	64.2 35.8
Sigma	Σ Σ^+	$1/2^+$	1	1	0	1189	0.8×10^{-10} s	$p\pi^0$, $n\pi^+$	51.6, 48.4
	Σ^0	$1/2^+$	1	0	0	1192	5.8×10^{-20} s	$\Lambda\gamma$	100
	Σ^-	$1/2^+$	1	-1	0	1197	1.5×10^{-10} s	$n\pi^-$	100
Xi	Ξ Ξ^0	$1/2^+$	$\frac{1}{2}$	$\frac{1}{2}$	-1	1315	2.9×10^{-10} s	$\Lambda\pi^0$	100
	Ξ^-	$1/2^+$	$\frac{1}{2}$	$-\frac{1}{2}$	-1	1321	1.6×10^{-10} s	$\Lambda\pi^-$	100
Omega	Ω^-	$3/2^+$	0	0	-2	1672	0.8×10^{-10} s	ΛK^-, $\Xi^0\pi^-$ $\Xi^-\pi^0$	68.6, 23.6 8

$$|p\rangle=\begin{pmatrix}1\\0\end{pmatrix},\quad |n\rangle=\begin{pmatrix}0\\1\end{pmatrix}$$

$$\rightarrow \quad I=\frac{1}{2}$$

$$|\Sigma^+\rangle=\begin{pmatrix}1\\0\\0\end{pmatrix},\quad |\Sigma^0\rangle=\begin{pmatrix}0\\1\\0\end{pmatrix},\quad |\Sigma^-\rangle=\begin{pmatrix}0\\0\\1\end{pmatrix}\quad \rightarrow I=1$$

☞Low Mass baryons - II

Properties of low-mass baryons

Name	Symbol	Spin (parity) $J^{(p)}$	T Isospin	T_3 Isospin projection	Hyper charge	Mass [MeV]	τ Lifetime	Main decay	Branching ratio [%]
Nucleon	N p	$1/2^+$	$\frac{1}{2}$	$\frac{1}{2}$	1	938.3	∞	—	
	N n	$1/2^+$	$\frac{1}{2}$	$-\frac{1}{2}$	1	939.6	15 min	$pe^-\bar{\nu}_e$	100
Hyperons									
Lambda	Λ^0	$1/2^+$	0	0	0	1116	2.6×10^{-10} s	$p\pi^-$	64.2
								$n\pi^0$	35.8
Sigma	Σ Σ^+	$1/2^+$	1	1	0	1189	0.8×10^{-10} s	$p\pi^0$, $n\pi^+$	51.6, 48.4
	Σ Σ^0	$1/2^+$	1	0	0	1192	5.8×10^{-20} s	$\Lambda\gamma$	100
	Σ Σ^-	$1/2^+$	1	-1	0	1197	1.5×10^{-10} s	$n\pi^-$	100
Xi	Ξ Ξ^0	$1/2^+$	$\frac{1}{2}$	$\frac{1}{2}$	-1	1315	2.9×10^{-10} s	$\Lambda\pi^0$	100
	Ξ Ξ^-	$1/2^+$	$\frac{1}{2}$	$-\frac{1}{2}$	-1	1321	1.6×10^{-10} s	$\Lambda\pi^-$	100
Omega	Ω^-	$3/2^+$	0	0	-2	1672	0.8×10^{-10} s	ΛK^-, $\Xi^0\pi^-$	68.6, 23.6
								$\Xi^-\pi^0$	8

$$|p\rangle=\begin{pmatrix}1\\0\end{pmatrix},\quad |n\rangle=\begin{pmatrix}0\\1\end{pmatrix}$$

$$\rightarrow \quad I=\frac{1}{2}$$

$$|\Xi^0\rangle=\begin{pmatrix}1\\0\end{pmatrix},\quad |\Xi^-\rangle=\begin{pmatrix}0\\1\end{pmatrix}$$

$$\rightarrow \quad I=\frac{1}{2}$$

But different sets

→ Introduce Hypercharge

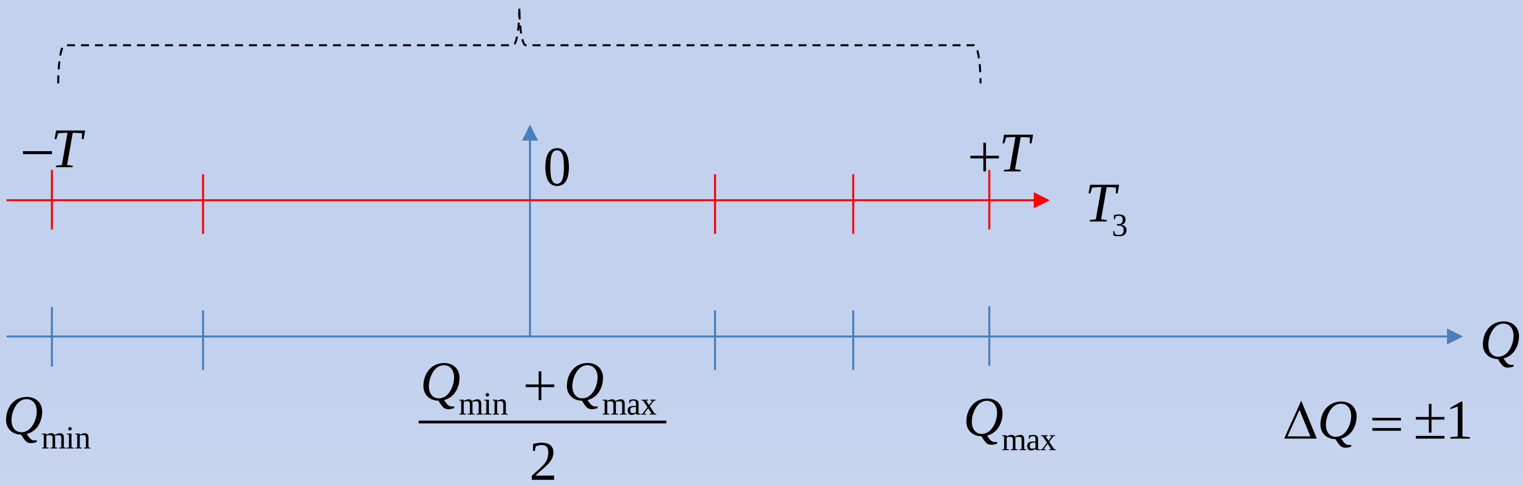
☞Properties of the baryon resonances

Properties of the baryon resonances

Symbol		J^P	Q	T	T_3	Y	Mass [MeV]	Lifetime τ [s]	Γ [MeV]	Main decay channels	Resonant partial waves
N^*	Δ^{++}	$3/2^+$	2				1232 ± 2	5.49×10^{-24}	120	$N\pi$	$P_{33}\,\pi p$
	Δ^{+}	$3/2^+$	1								
	Δ^{0}	$3/2^+$	0								
	Δ^{-}	$3/2^+$	-1								
N'	N'^{+}	$1/2^+$	1				1440 ± 40	3.13×10^{-24}	210	$N\pi$, $N\pi\pi$	$P_{11}\,\pi p$
	N'^{0}	$1/2^+$	0								
Λ^*		$1/2^-$	0				1405 ± 5	1.65×10^{-23}	40	$\Sigma\pi$	$S_{01}\,K^-p$
Σ^*	Σ^{*1}	$3/2^+$	1				1382.3 ± 0.4	1.78×10^{-25}	37	$\Lambda\pi$, $\Sigma\pi$	$P_{13}\,K^-p$
	Σ^{*0}	$3/2^+$	0				1382.0 ± 2.5				
	Σ^{*-1}	$3/2^+$	-1				1387.4 ± 0.6				
Ξ^*	Ξ^{*0}	$3/2^+$	0				1531.8 ± 0.3	9.4×10^{-23}	7	$\Xi\pi$	P
	Ξ^{*-}	$3/2^+$	-1				1535.0 ± 0.6				

☞Each Isospin symmetric state from a representation of the of total isospin I=T the states in a representation have different T_3 but also different charge Q.

$$2T+1 \text{ States separated by } \Delta T = \pm 1$$



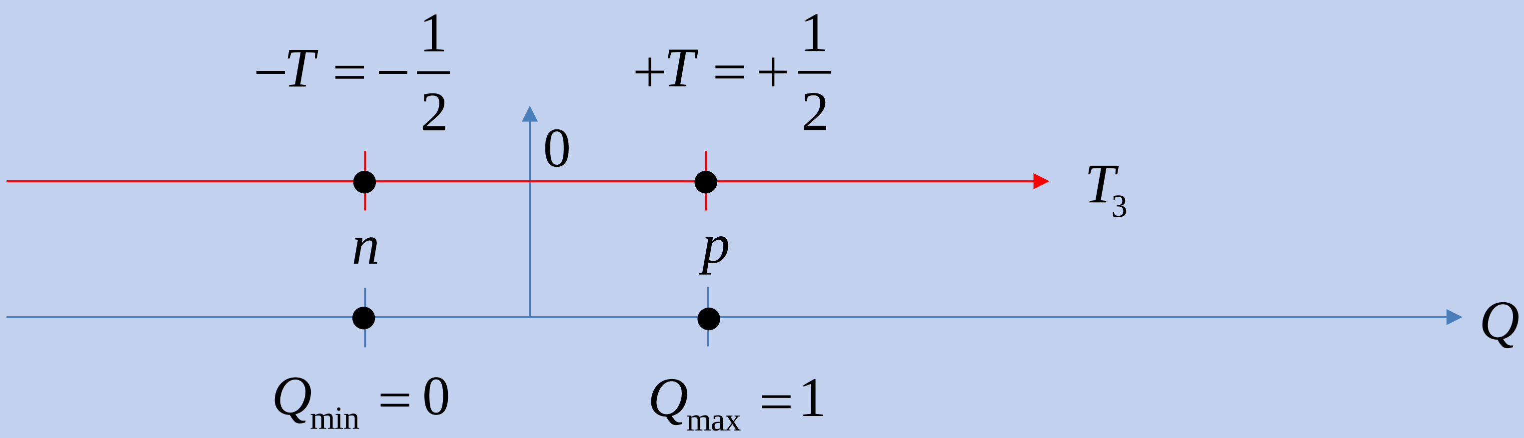
Determination of Isospin $\quad 2T = Q_{\max} - Q_{\min}$

When T3 increases by 1 so does Q $\quad T_3 = Q + [\text{State independent constant}]$

Introduce Hypercharge common to all states in this set $\quad Q = \frac{1}{2}Y + T_3$

$$\rightarrow \quad Q_{\max} = \frac{1}{2}Y + T, \quad Q_{\min} = \frac{1}{2}Y - T \quad \rightarrow \quad Y = Q_{\max} + Q_{\min}$$

☞Example I: proton (p) and Neutron (n):



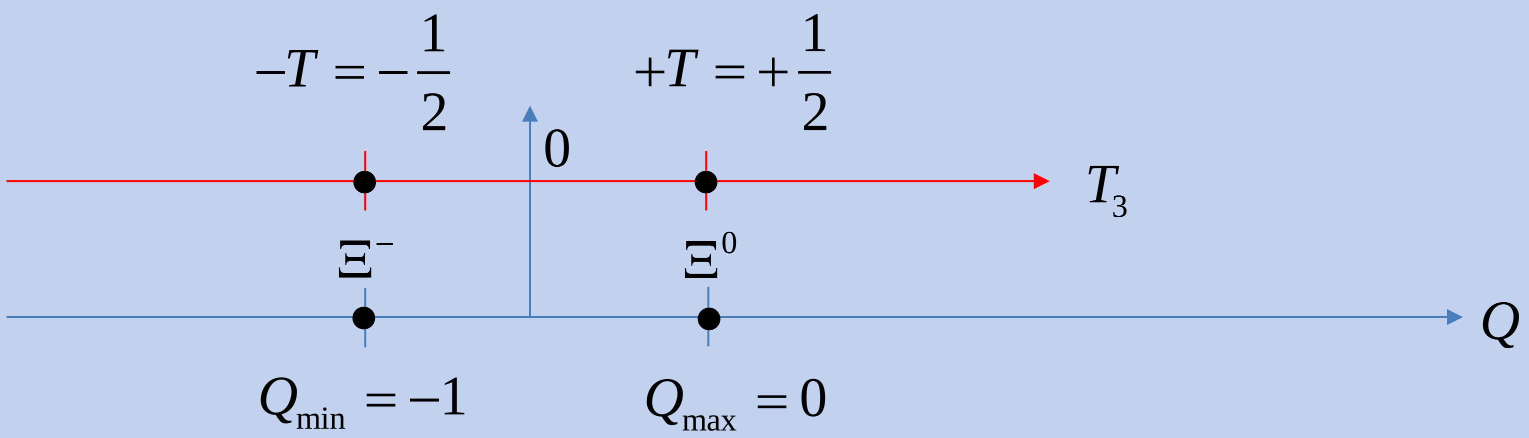
Determination of Isospin $\quad 2T = Q_{\max} - Q_{\min} \quad \rightarrow T = \frac{1}{2}$

Introduce Hypercharge $\quad Q = \frac{1}{2}Y + T_3 \quad Y = Q_{\max} + Q_{\min} = 1$

$$\mathrm{p} \rightarrow \quad T=\frac{1}{2}, \quad T_3 = +\frac{1}{2}, \quad Y=1$$

$$\mathrm{n} \rightarrow \quad T=\frac{1}{2}, \quad T_3 = -\frac{1}{2}, \quad Y=1$$

☞Example I: Xi (Ξ) states:



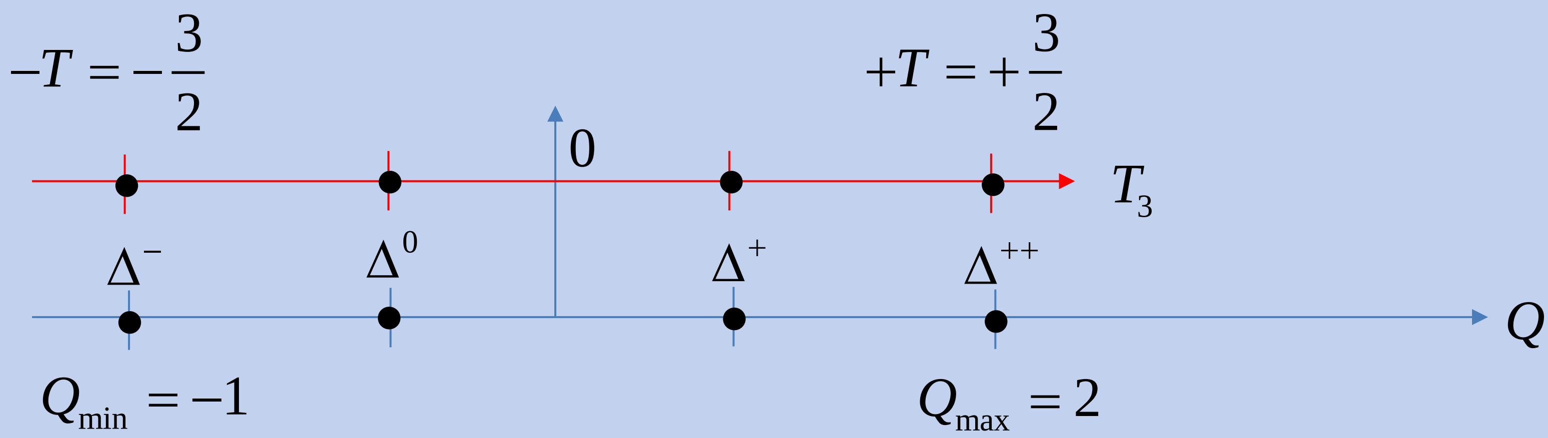
Determination of Isospin $\quad 2T = Q_{\max} - Q_{\min} \quad \rightarrow T = \frac{1}{2}$

Introduce Hypercharge $\quad Q = \frac{1}{2}Y + T_3 \quad Y = Q_{\max} + Q_{\min} = -1$

$$\Xi^- \rightarrow T = \frac{1}{2}, \quad T_3 = +\frac{1}{2}, \quad Y = -1$$

$$\Xi^0 \rightarrow T = \frac{1}{2}, \quad T_3 = -\frac{1}{2}, \quad Y = -1$$

☞Example III: Delta Δ resonance :



Determination of Isospin $\quad 2T = Q_{\max} - Q_{\min} \quad \rightarrow T = \frac{3}{2}$

Introduce Hypercharge $\quad Q = \frac{1}{2}Y + T_3 \quad Y = Q_{\max} + Q_{\min} = 1$

$$\Delta^{++} \rightarrow T = \frac{3}{2},\ T_3 = +\frac{3}{2},\ Y = 1 \qquad \Delta^0 \rightarrow T = \frac{3}{2},\ T_3 = -\frac{1}{2},\ Y = 1$$

$$\Delta^{+} \rightarrow T = \frac{3}{2},\ T_3 = +\frac{1}{2},\ Y = 1 \qquad \Delta^- \rightarrow T = \frac{3}{2},\ T_3 = -\frac{3}{2},\ Y = 1$$

☞Example IV: Quantum number of a nuclei composed of Z number of (p) and N (n)

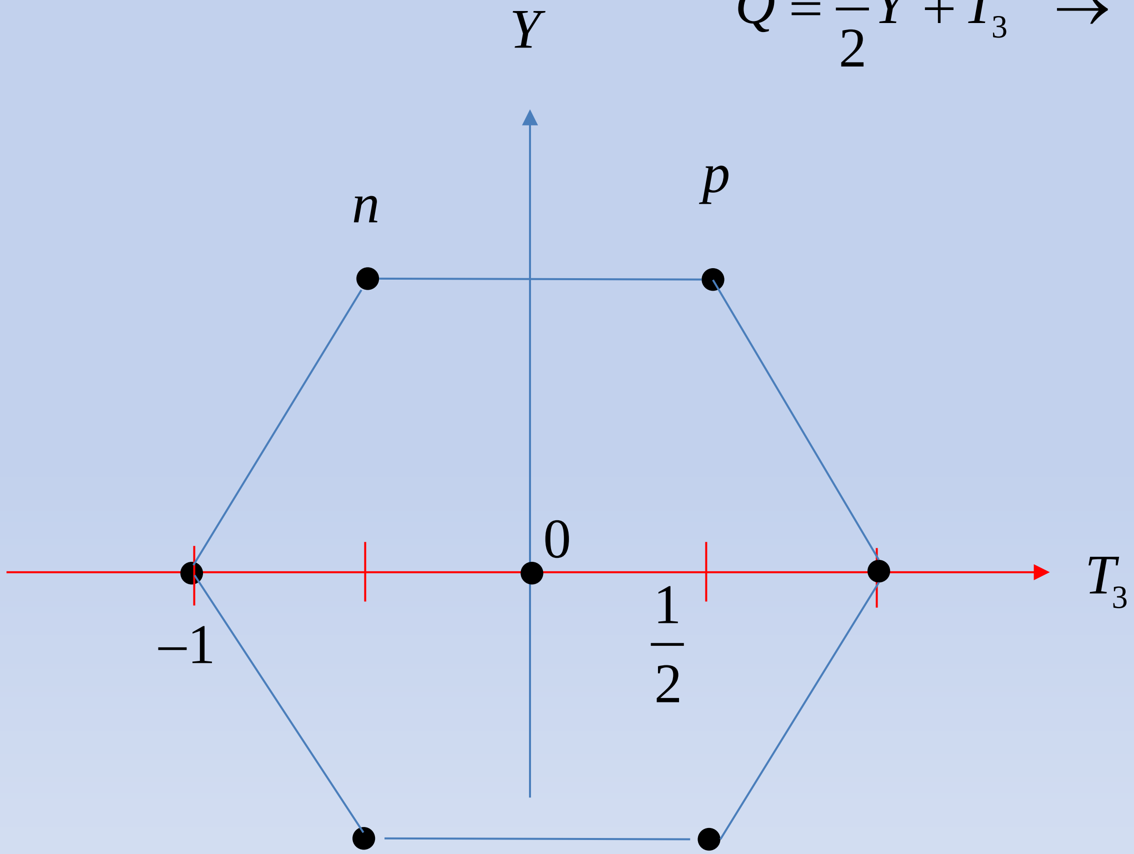
Only T3 and Y is well determined

$$T_3 = \sum_{i=p,n} T_3(i) = {}^1\!/_2 (Z - N)$$

From $$Q = \frac{1}{2} Y + T_3 \quad \rightarrow Z = {}^1\!/_2 Y + T_3 \quad \rightarrow \quad Y = Z + N$$

☞plot of T3 and Y

$$Q = \frac{1}{2}Y + T_3 \quad \rightarrow \quad Y = -2T_3 + 2Q$$



☞prediction of particle before observation