predictions for excited strange baryons

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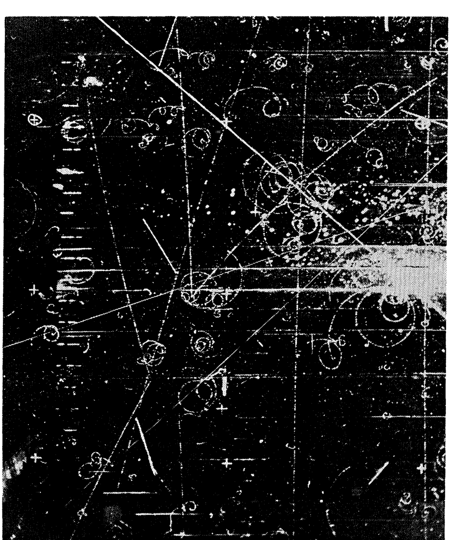
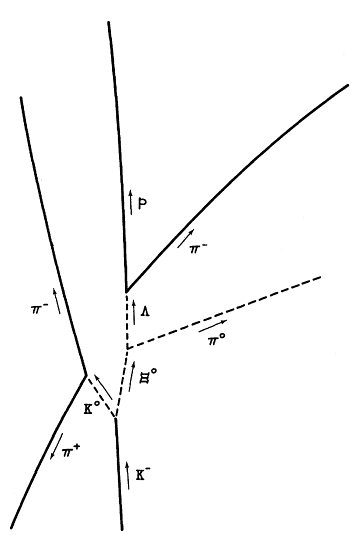
KL2016 @ JLab





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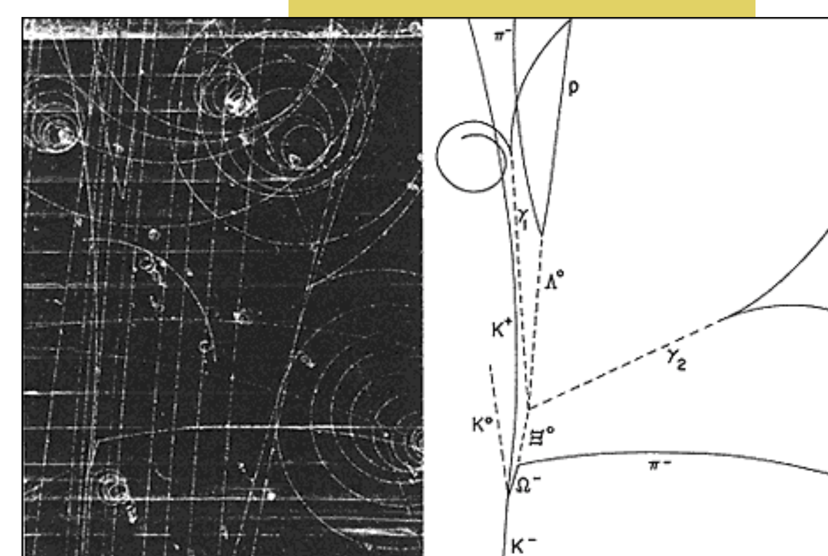
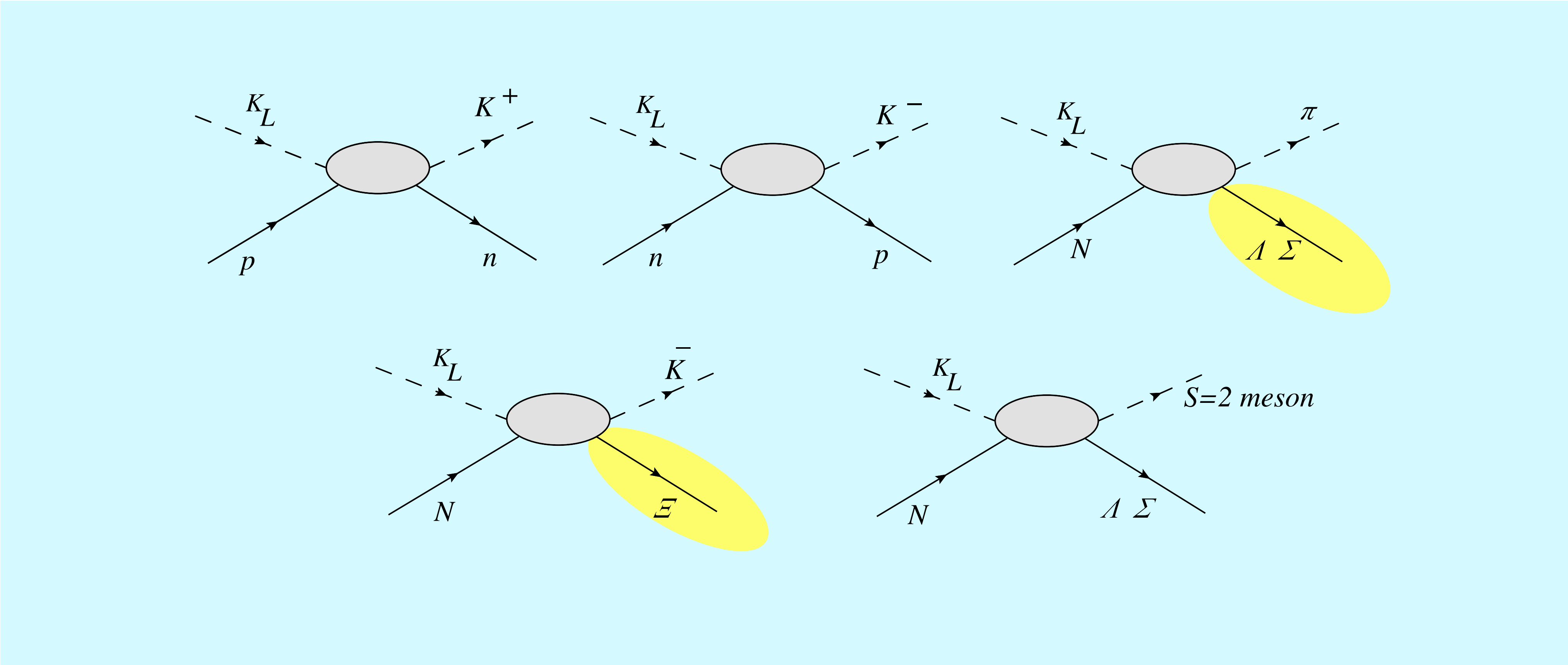


The interest of Kaon beams

- Study of electro-weak interactions in K mesons
- Production of excited K* mesons
- Production of strange baryons
- Search for exotic mesons and baryons

K_L beam: S=±1 in one shot (talks by Filippi and Manley)



Outline

- Some of the key questions concerning strange baryons -- hyperons
- Present status of excited hyperons
- Symmetries in excited baryons
- Predicting excited hyperon masses
- Other possible predictions
- Comments

Some key questions

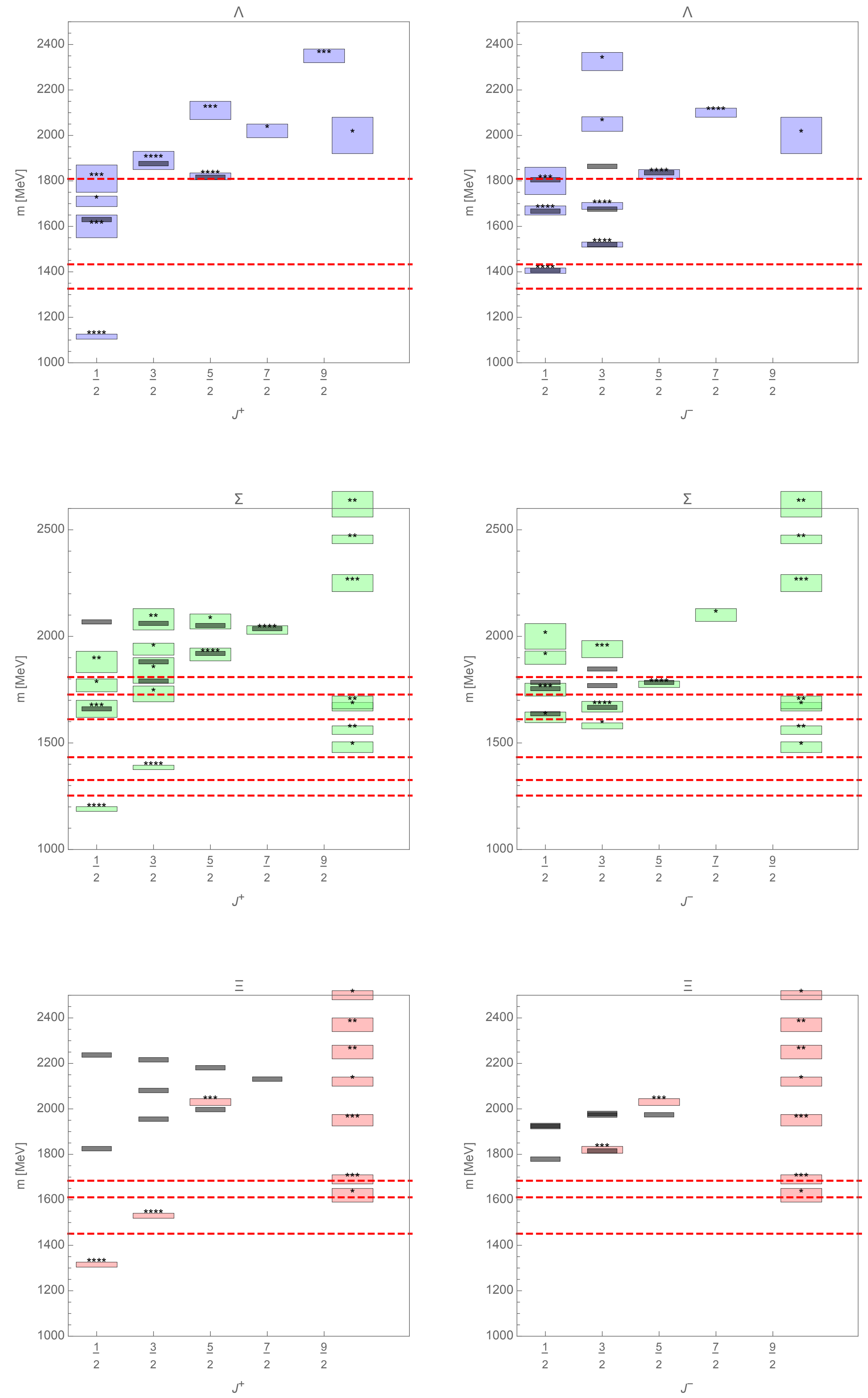
- Missing hyperon states: complete SU(3) multiplets require (ignoring isospin)

$$\begin{array}{rr} & PDG \\ \#\Sigma = \#\Xi = \#N + \#\Delta & 26; 12; 49 \\ \#\Omega = \#\Delta & 4; 22 \\ \#\Lambda = \#N + \#\text{singlets} & 18; 29 \end{array}$$

- Should all observed hyperons belong into SU(3) multiplets?: dynamically generated states may not
- Should baryons filling SU(3) multiplets also fill SU(6) multiplets?: probably yes
- Do we have sufficient inputs and theoretical tools to make some predictions: yes!

Present status of hyperons from PDG

1/Nc baryon mass formulas



Symmetries in excited baryons

Flavor SU(3): broken by $m_s >> m_{u,d}$

It should be a good approximate symmetry because

$$m_s << \text{hadronic scales}$$

Expect baryons to fill SU(3) multiplets: 8s, 10s and 1s.
GS baryons (low lying 8 and 10) complete
What about others? -- only one in PDG!

$N_{3/2^-}$	1532
$\Lambda_{3/2^-}$	1676
$\Sigma_{3/2^-}$	1667
$\Xi_{3/2^-}$	1815

GMO relation

$$2(N_{3/2} + \Xi_{3/2}) - 3\Lambda_{3/2} - \Sigma_{3/2} = -19 \pm 26\ MeV$$

Additional symmetries in baryons

QCD observables admit expansions in $m_{u,d,s}$ and in $1/N_c$

Consequence of the $1/N_c$ expansion for baryons: approximate spin-flavor $SU(2N_f) = SU(6)$ symmetry violated at order $1/N_c$ or higher.

How good is $SU(6)$?

GS mass relations: Gursey-Radicati with $1/N_c$ power counting included

$$M_{GS} = c_1\, N_c + \frac{c_{HF}}{N_c}\,(S^2 - \frac{3}{4}N_c) - c_{\mathcal{S}}\frac{m_s - m_{u,d}}{\Lambda}\,\mathcal{S} + \mathcal{O}(1/N_c^2; m_s/N_c)$$

	$\Sigma - \Lambda = \mathcal{O}(m_s/N_c)$	74 MeV	
GMO	$\Xi_8 - \Sigma_8 = \frac{1}{2}(3\Lambda - \Sigma_8) - N$	128 vs 141 MeV	deviation is $\mathcal{O}((m_s - m_{u,d})^2/N_c)$
ES	$\Sigma_{10} - \Delta = \Xi_{10} - \Sigma_{10}$	153 vs 145	
”	$\Omega^- - \Xi_{10} = \Xi_{10} - \Sigma_{10}$	142 vs 145	
8-10	$\Sigma_{10} - \Sigma_8 = \Xi_{10} - \Xi_8$	212 vs 195	deviation is $\mathcal{O}(1/N_c^2)$

A test with the N & Δ axial couplings

large N_c prediction $\quad g_A^{NN} = g_A^{N\Delta} = g_A^{\Delta\Delta}$

	g_A^{NN}	$g_A^{N\Delta}$	$g_A^{\Delta\Delta}$
Exp	1.27	1.24	–
Lattice QCD (ETM)	1.17	1.07	0.98

deviations are $\mathcal{O}(1/N_c^2) \sim 10\%$: OK!

Many other tests with the octet and decuplet axial couplings

SU(6) broken according to 1/Nc power counting works remarkably well in the GS 8 and 10

SU(6) plays a key role in baryon ChPT for improving the chiral expansion as well

Excited baryons

$$SU(6) \times O(3) \to \text{Large } N_c \text{ QCD} \to SU(6)$$

Observed fact: in all analyzed observables (masses, partial widths, photocouplings) operators involving factors of $SU(6)$ and $O(3)$ operators have small coefficients:

$\mathcal{O}(1/N_c)$ suppressed in transition and in $SU(6)$ symmetric states (56-plet)
$\mathcal{O}(1/N_c^0)$ in $SU(6)$ mixed-symmetric states (70-plet)

Expansion in $1/N_c$ and if necessary in "spin-orbit" couplings

Mass formulas

$$M(R(SU(6)), L, J, R(SU(3)), Y) = M_0(R(SU(6)), L) + \delta M(R(SU(6)), L, J, R(SU(3)), Y)$$

$$R(SU(6)) = 56,\ 70,\ 20?, \qquad R(SU(3)) = 1,\ 8,\ 10$$

δM expanded in $m_s - m_{u,d}$ and in $1/N_c$

More predictivity: through additional mass relations

$[56,2^+]$ mass relations

$[56,2^+]$	*masses*	$[MeV]$
State	$1/N_c$	*PDG*
$N_{3/2}$	1674 ± 15	1700 ± 50
$\Lambda_{3/2}$	1876 ± 39	1880 ± 30
$\Sigma_{3/2}$	1881 ± 25	(1840)
$\Xi_{3/2}$	2081 ± 57	
$N_{5/2}$	1689 ± 14	1683 ± 8
$\Lambda_{5/2}$	1816 ± 33	1820 ± 5
$\Sigma_{5/2}$	1920 ± 24	1918 ± 18
$\Xi_{5/2}$	1997 ± 49	
$\Delta_{1/2}$	1897 ± 32	1895 ± 25
$\Sigma_{1/2}$	2068 ± 52	
$\Xi_{1/2}$	2237 ± 88	
$\Omega_{1/2}$	2408 ± 127	
$\Delta_{3/2}$	1906 ± 27	1935 ± 35
$\Sigma'_{3/2}$	2061 ± 44	(2080)
$\Xi'_{3/2}$	2216 ± 76	
$\Omega_{3/2}$	2373 ± 110	
$\Delta_{5/2}$	1921 ± 21	1895 ± 25
$\Sigma'_{5/2}$	2051 ± 37	(2070)
$\Xi'_{5/2}$	2181 ± 64	
$\Omega_{5/2}$	2313 ± 94	
$\Delta_{7/2}$	1942 ± 27	1950 ± 10
$\Sigma_{7/2}$	2036 ± 44	2033 ± 8
$\Xi_{7/2}$	2131 ± 76	
$\Omega_{7/2}$	2229 ± 110	

	$\mathcal{O}(\Lambda/N_c^2)$		$Exp[MeV]$
	$\frac{1}{2}(\Delta_{5/2} - \Delta_{3/2} - N_{5/2} + N_{3/2})$	$=$	-12 ± 33
	$\sqrt{\frac{2}{53}}(\Delta_{7/2} - \Delta_{5/2} - \frac{7}{5}(N_{5/2} - N_{3/2}))$	$=$	15 ± 15
	$\frac{1}{2\sqrt{5}}(\Delta_{7/2} - \Delta_{1/2} - 3(N_{5/2} - N_{3/2}))$	$=$	24 ± 34
	$\frac{1}{2\sqrt{3}}(\Lambda_{5/2} - \Lambda_{3/2} + \Sigma_{5/2} - \Sigma_{3/2} - 2(\Sigma'_{5/2} - \Sigma'_{3/2}))$	$=$	11 ± 36
	$\frac{1}{\sqrt{218}}(7\,\Sigma'_{3/2} + 5\,\Sigma_{7/2} - 12\,\Sigma'_{5/2})$	$=$	-7 ± 38
	$\frac{1}{\sqrt{57}}(4\,\Sigma_{1/2} + \Sigma_{7/2} - 5\,\Sigma'_{3/2})$		
	$\mathcal{O}(m_s/N_c^2)$		$Exp[MeV]$
	$\frac{1}{\sqrt{3346}}(8\Lambda_{3/2} - 8N_{3/2} + 37\Lambda_{5/2} - 22N_{5/2} - 15\Sigma_{5/2} - 30\Sigma_{7/2} + 30\Delta_{7/2})$	$=$	8.5 ± 12
	$\frac{1}{2\sqrt{13}}(\Lambda_{5/2} - \Lambda_{3/2} + 3(\Sigma_{5/2} - \Sigma_{3/2}) - 4(N_{5/2} - N_{3/2}))$	$=$	34 ± 34
(GMO)	$2(N + \Xi)$	$=$	$3\,\Lambda + \Sigma$
(EQS)	$\Sigma - \Delta$	$=$	$\Xi - \Sigma = \Omega - \Xi$

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$[70, 1^-]$ mass relations

Masses [MeV]		
State	*Exp*	*Large N_c*
$N_{1/2}$	1538 ± 18	1541
$\Lambda_{1/2}$	1670 ± 10	1667
$\Sigma_{1/2}$	(1620)	1637
$\Xi_{1/2}$	(1690)	1779
$N_{3/2}$	1523 ± 8	1532
$\Lambda_{3/2}$	1690 ± 5	1676
$\Sigma_{3/2}$	1675 ± 10	1667
$\Xi_{3/2}$	1823 ± 5	1815
$N'_{1/2}$	1660 ± 20	1660
$\Lambda'_{1/2}$	1785 ± 65	1806
$\Sigma'_{1/2}$	1765 ± 35	1755
$\Xi'_{1/2}$		1927
$N'_{3/2}$	1700 ± 50	1699
$\Lambda'_{3/2}$		1864
$\Sigma'_{3/2}$		1769
$\Xi'_{3/2}$		1980
$N_{5/2}$	1678 ± 8	1671
$\Lambda_{5/2}$	1820 ± 10	1836
$\Sigma_{5/2}$	1775 ± 5	1784
$\Xi_{5/2}$		1974
$\Delta_{1/2}$	1645 ± 30	1645
$\Sigma''_{1/2}$		1784
$\Xi''_{1/2}$		1922
$\Omega_{1/2}$		2061
$\Delta_{3/2}$	1720 ± 50	1720
$\Sigma''_{3/2}$		1847
$\Xi''_{3/2}$		1973
$\Omega_{3/2}$		2100
$\Lambda''_{1/2}$	1407 ± 4	1407
$\Lambda''_{3/2}$	1520 ± 1	1520

GMO, ES & 15 1-8-10 relations

Sample

$\mathcal{O}(m_s/N_c^2; m_s^2)$

$$\frac{1}{\sqrt{16930}}\left(14(\tilde{\Lambda}_{3/2} + \tilde{\Lambda}'_{3/2}) + 63\tilde{\Lambda}_{5/2} + 36(\tilde{\Sigma}_{1/2} + \tilde{\Sigma}'_{1/2}) - 68(\tilde{\Lambda}_{1/2} + \tilde{\Lambda}'_{1/2}) - 27\tilde{\Sigma}_{5/2}\right)$$

$$\frac{1}{\sqrt{1570}}\left(14(\tilde{\Sigma}_{3/2} + \tilde{\Sigma}'_{3/2}) + 21\tilde{\Lambda}_{5/2} - 9\tilde{\Sigma}_{5/2} - 18(\tilde{\Lambda}_{1/2} + \tilde{\Lambda}'_{1/2}) - 2(\tilde{\Sigma}_{1/2} + \tilde{\Sigma}'_{1/2})\right)$$

$$\frac{1}{\sqrt{8066}}\left(14\tilde{\Sigma}''_{1/2} + 49\tilde{\Lambda}_{5/2} + 23(\tilde{\Sigma}_{1/2} + \tilde{\Sigma}'_{1/2}) - 45(\tilde{\Lambda}_{1/2} + \tilde{\Lambda}'_{1/2}) - 19\tilde{\Sigma}_{5/2}\right)$$

$$\frac{1}{2\sqrt{695}}\left(14\tilde{\Sigma}''_{3/2} + 28\tilde{\Lambda}_{5/2} + 11(\tilde{\Sigma}_{1/2} + \tilde{\Sigma}'_{1/2}) - 27(\tilde{\Lambda}_{1/2} + \tilde{\Lambda}'_{1/2}) - 10\tilde{\Sigma}_{5/2}\right)$$

PDG identified states are sufficient to predict masses of missing states up to higher order terms in 1/Nc and SU(3) breaking

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Only a reduced number of possible mass operators show to be important after fitting to the known masses

Checks with Lattice QCD

HSC R. Edwards et al (2013)

Fernando & JLG

$[56, 0^+]$

Relation	M_π[MeV]	
	391	524
$2(N+\Xi)-(3\Lambda+\Sigma)=0$	179±180	106±155
$\Sigma''-\Delta=\Xi''-\Sigma''=\Omega''-\Xi''$	13±45	-27±26
	84±40	41±49
	48±42	41±57
$\frac{1}{3}(\Sigma+2\Sigma'')-\Lambda-(\frac{2}{3}(\Delta-N))=0$	51±65	29±41
$\Sigma''-\Sigma=\Xi''-\Xi$	58±63	77±80
$3\Lambda+\Sigma-2(N+\Xi)+(\Omega''-\Xi''-\Sigma''+\Delta)=0$	144±189	174±170
$\Sigma''-\Delta+\Omega''-\Xi''-2(\Xi^*-\Sigma'')=0$	107±110	67±147

$[56, 2^+]$

Relation	M_π[MeV]		
	391	524	702
$2(N_{3/2}+\Xi_{3/2})-(3\Lambda_{3/2}+\Sigma_{3/2})=0$	98±126	49±173	0
$2(N_{5/2}+\Xi_{5/2})-(3\Lambda_{5/2}+\Sigma_{5/2})=0$	40±98	55±65	0
$\Sigma''_{1/2}-\Delta_{1/2}=\Xi''_{1/2}-\Sigma''_{1/2}=\Omega_{1/2}-\Xi''_{1/2}$	-13±110	36±33	0
	23±44	43±22	0
	85±54	35±19	0
$\Sigma''_{3/2}-\Delta_{3/2}=\Xi''_{3/2}-\Sigma''_{3/2}=\Omega_{3/2}-\Xi''_{1/2}$	48±46	36±23	0
	56±29	30±16	0
	45±31	41±15	0
$\Sigma''_{5/2}-\Delta_{5/2}=\Xi''_{5/2}-\Sigma''_{5/2}=\Omega_{5/2}-\Xi''_{5/2}$	35±40	34±26	0
	62±31	26±23	0
	57±34	52±18	0
$\Sigma''_{7/2}-\Delta_{7/2}=\Xi''_{7/2}-\Sigma''_{7/2}=\Omega_{7/2}-\Xi''_{7/2}$	38±38	35±25	0
	67±31	36±20	0
	59±31	22±18	0
$\Delta_{5/2}-\Delta_{3/2}-(N_{5/2}-N_{3/2})=0$	70±68	4±68	44±33
$(\Delta_{7/2}-\Delta_{5/2})-\frac{7}{5}(N_{5/2}-N_{3/2})=0$	68±78	2.5±92	75±41
$\Delta_{7/2}-\Delta_{1/2}-3(N_{5/2}-N_{3/2})=0$	129±175	13±192	133±74
$\frac{8}{15}(\Lambda_{3/2}-N_{3/2})+\frac{22}{15}(\Lambda_{5/2}-N_{5/2})$			
$-(\Sigma_{5/2}-\Lambda_{5/2})-2(\Sigma''_{7/2}-\Delta_{7/2})=0$	91±100	29±75	0
$\Lambda_{5/2}-\Lambda_{3/2}+3(\Sigma_{5/2}-\Sigma_{3/2})-4(N_{5/2}-N_{3/2})=0$	10±207	10±272	0
$\Lambda_{5/2}-\Lambda_{3/2}+\Sigma_{5/2}-\Sigma_{3/2}-2(\Sigma''_{5/2}-\Sigma''_{3/2})=0$	111±81	12±72	87±59
$7(\Sigma''_{3/2}-\Sigma''_{7/2})-12(\Sigma''_{5/2}-\Sigma''_{7/2})=0$	44±319	39±268	67±266
$4(\Sigma''_{1/2}-\Sigma''_{7/2})-5(\Sigma''_{3/2}-\Sigma''_{7/2})=0$	83±170	87±104	58±161

$[70, 1^-]$

Relation	M_π [MeV]	
	391	524
$14(S_{\Lambda_{3/2}}+S_{\Lambda'_{3/2}})+63S_{\Lambda_{5/2}}+36(S_{\Sigma_{1/2}}+S_{\Sigma'_{1/2}})$		
$-68(S_{\Lambda_{1/2}}+S_{\Lambda'_{1/2}})-27S_{\Sigma_{5/2}}=0$	9.4±40	0.96±34
$14(S_{\Sigma_{3/2}}+S_{\Sigma'_{3/2}})+21S_{\Lambda_{5/2}}-9S_{\Sigma_{5/2}}$		
$-18(S_{\Lambda_{1/2}}+S_{\Lambda'_{1/2}})-2(S_{\Sigma_{1/2}}+S_{\Sigma'_{1/2}})=0$	37±45	5.4±38
$14\,S_{\Sigma''_{1/2}}+49S_{\Lambda_{5/2}}+23(S_{\Sigma_{1/2}}+S_{\Sigma'_{1/2}})$		
$-45(S_{\Lambda_{1/2}}+S_{\Lambda'_{1/2}})-19S_{\Sigma_{5/2}}=0$	9.4±40	0.7±34
$14\,S_{\Sigma''_{3/2}}+28S_{\Lambda_{5/2}}+11(S_{\Sigma_{1/2}}+S_{\Sigma'_{1/2}})$		
$-27(S_{\Lambda_{1/2}}+S_{\Lambda'_{1/2}})-10S_{\Sigma_{5/2}}=0$	0.8±40	0.1±33

mass relations implied by SU(6) broken at order 1/Nc hold remarkably well

Excited hyperons: mass predictions and puzzles

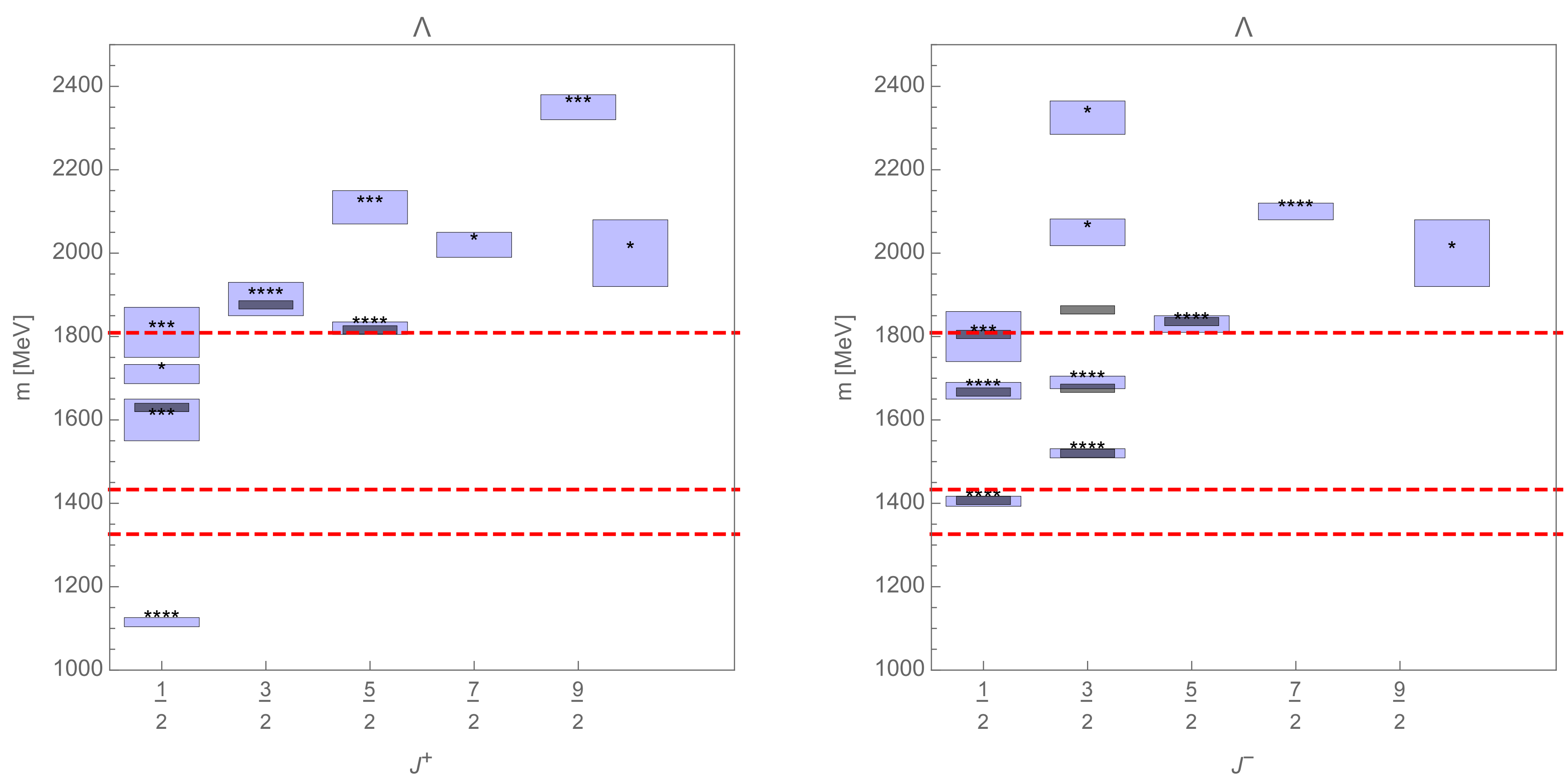
Mass predictions based on SU(6)xO(3)

Λs

- One missing state in the $[70, 1^-]$:
  prediction: $\Lambda_{3/2^-}(1830)$

- PDG: $\Lambda_{1/2^+}(1810)$ a bit too light to fit into higher excited multiplets such as $[70, 0^+]$ or $[70, 2^+]$ Matagne & Stancu
  sits exactly at the ΞK threshold

- Heavier states poorly established or need higher excited spin-flavor multiplets: too sparse for predictions



Σs

- Positive parity predicted masses:

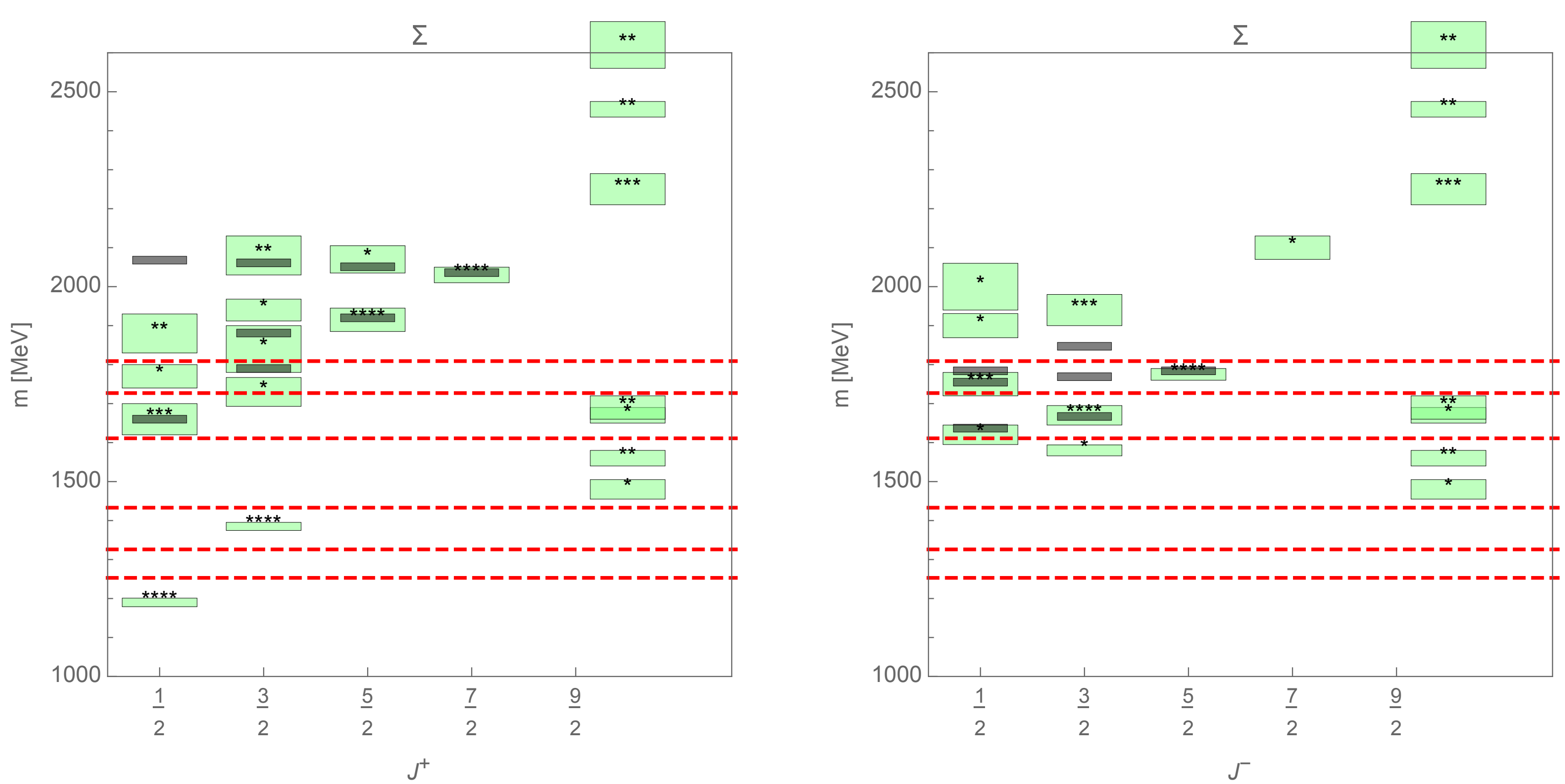
$\Sigma_{1/2^+}(1790)$ in a decuplet in $[56, 0^+]$
$\Sigma_{1/2^+}(2068)$ in a decuplet in $[56, 2^+]$
$\Sigma_{3/2^+}(1880)$ in an octet in $[56, 2^+]$
$\Sigma_{3/2^+}(2060)$ in a decuplet in $[56, 2^+]$
$\Sigma_{5/2^+}(2050)$ in a decuplet in $[56, 2^+]$

Most match with existing PDG entries

- Negative parity predicted masses:

$\Sigma_{1/2^-}(1637)$ in an octet in $[70, 1^-]$
$\Sigma_{3/2^-}(1770)$ in an octet in $[70, 1^-]$
$\Sigma_{1/2^-}(1785)$ in a decuplet in $[70, 1^-]$
$\Sigma_{3/2^-}(1847)$ in a decuplet in $[70, 1^-]$

- Puzzles: several * and ** PDG entries seem too light to fit in any multiplet



Ξs

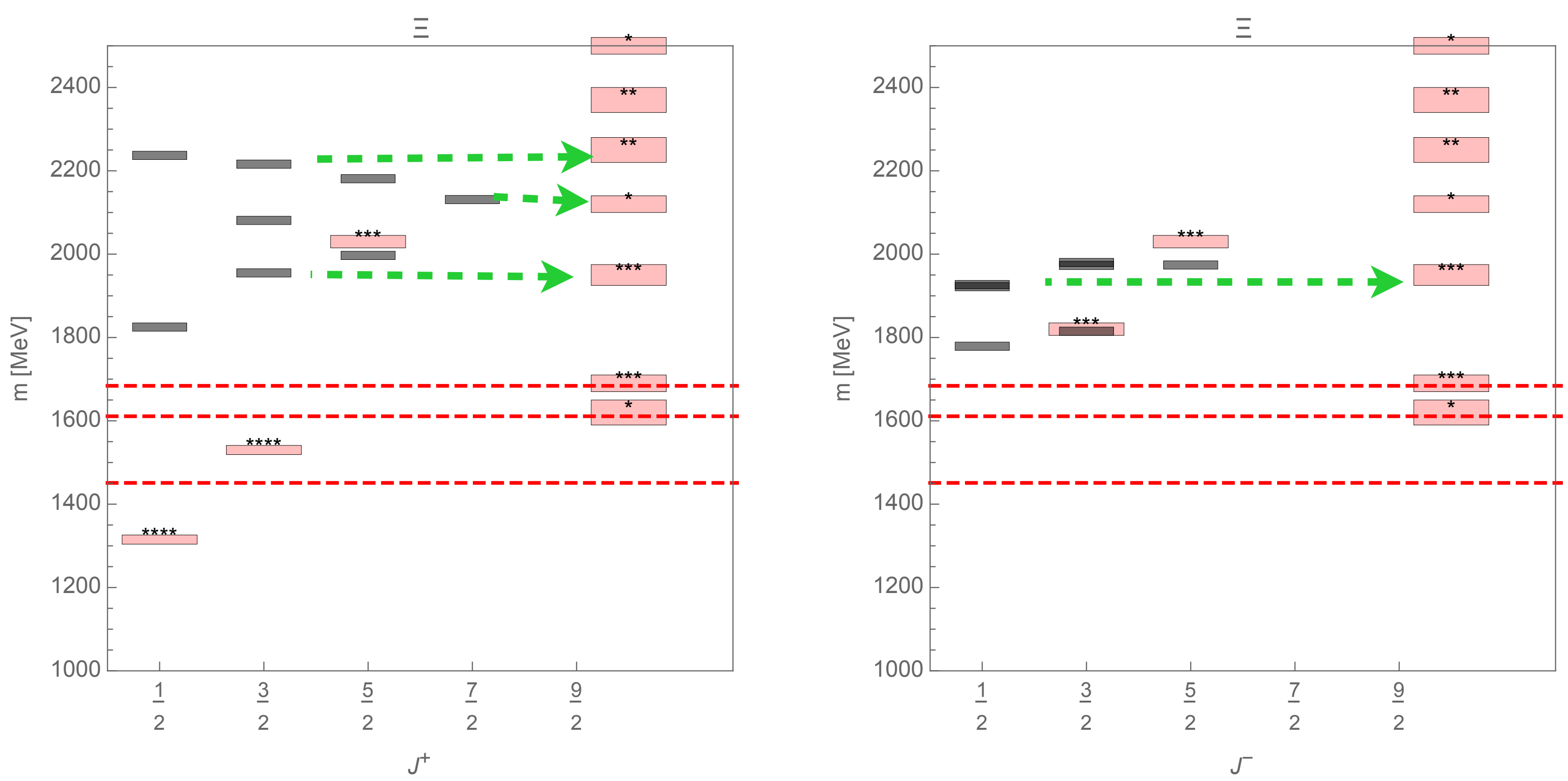
- Lightest PDG entries coincide with thresholds. Cannot be described within any multiplet.

- Several possible identifications of predictions with PDG listings

- $\Xi_{5/2}(2030)$ *** is best identified with a state in the $[56, 2^+]$

- 12 predictions and a few possible matchings with listed PDG states

- Two remaining mass states should be in other multiplets.



Other observables: partial decay widths

[70,1⁻] decay relations: LO=exact SU(4) limit

$\tilde{\Gamma}$: reduced widths: phase space factors removed

S-wave

$$\frac{\tilde{\Gamma}(N(1535)\to N\pi)-\tilde{\Gamma}(N(1650)\to N\pi)}{\tilde{\Gamma}(N(1535)\to N\pi)+\tilde{\Gamma}(N(1650)\to N\pi)}=\frac{1}{5}(3\cos 2\theta_{N_1}-4\sin 2\theta_{N_1})\to\theta_{N_1}=0.46(10)\ or\ 1.76(10)$$

$$\frac{\tilde{\Gamma}(N(1535)\to N\eta)-\tilde{\Gamma}(N(1650)\to N\eta)}{\tilde{\Gamma}(N(1535)\to N\eta)+\tilde{\Gamma}(N(1650)\to N\eta)}=\sin 2\theta_{N_1}\to\theta_{N_1}=0.51(27)$$

$$\tilde{\Gamma}(N(1535)\to N\pi)+\tilde{\Gamma}(N(1650)\to N\pi)=\tilde{\Gamma}(\Delta(1535)\to\Delta\pi)\quad 51(10)\ (th)\ vs\ 31(15)\ (exp)$$

$$\frac{\tilde{\Gamma}(\Delta(1620)\to N\pi)}{\tilde{\Gamma}(\Delta(1700)\to\Delta\pi)}=\quad 0.1\ (th)\quad vs\quad 0.29(15)\ (exp)$$

D-wave

$$2\tilde{\Gamma}(\Delta(1620)\to\Delta\pi)+\tilde{\Gamma}(\Delta(1700)\to\Delta\pi)=15\tilde{\Gamma}(\Delta(1620)\to N\pi)+32\tilde{\Gamma}(\Delta(1700)\to N\pi)$$

$$5.9(1.9)\quad vs\quad 8.3(2.3)$$

$$\tilde{\Gamma}(N(1535)\to\Delta\pi)+\tilde{\Gamma}(N(1650)\to\Delta\pi)+11\tilde{\Gamma}(\Delta(1620)\to\Delta\pi)=132\tilde{\Gamma}(\Delta(1700)\to N\pi)+90\tilde{\Gamma}(N(1675)\to N\pi)$$

$$32(11)\quad vs\quad 41(10)$$

Known hyperons partial decay widths in the 70-plet

	$\Lambda(1670)$				$\Lambda(1690)$				
	$\bar{K}N$	$\eta\Lambda$	$\pi\Sigma$	$\pi\Sigma^*$	$\pi\Sigma^*$		$\bar{K}N$	$\eta\Lambda$	$\pi\Sigma$
PW	S	S	S	D	S	D	D	D	D
LO	113(24)	0.11(0.12)	1.8(2.0)	0.16(0.09)	7.3(3.5)	9(1)	60(6)	~ 0	9.0(0.9)
NLO	9(15)	6.1(4.3)	15(11)	0.04(0.10)	114(49)	2.1(1.5)	16(5)	~ 0	5.3(2.9)
Exp	9.4(3.6)	6.6(3.6)	15(7.5)				15(4)		18(6.7)

	$\Sigma(1670)$				
	$\pi\Sigma^*$		$\bar{K}N$	$\pi\Lambda$	$\pi\Sigma$
PW	S	D	D	D	D
LO	1.5(0.7)	1.5(0.2)	2.1(0.5)	4.8(0.5)	46(5)
NLO	4(11)	1.5(0.9)	2.5(1.4)	7.0(2.9)	28(11)
Exp			6(2.7)	6(3.6)	27(12.7)

	$\Lambda(1800)$				$\Lambda(1830)$				
	$\bar{K}N$	$\eta\Lambda$	$\pi\Sigma$	$\pi\Sigma^*$	$\bar{K}N$	$\eta\Lambda$	$\pi\Sigma$	$K\Xi$	$\pi\Sigma^*$
PW	S	S	S	D	D	D	D	D	D
LO	43(13)	30(4)	150(20)	3.0(1.6)	3.0(1.6)	3.5(0.3)	69(6)	~ 0	54(7)
NLO	100(73)	94(47)	109(25)	5.9(5.2)	12(4)	9.6(2.5)	38(11)	~ 0	57(18)
Exp	98(40)				5.5(3.4)		46.7(22)		

	$\Sigma(1750)$					
	$\bar{K}N$	$\pi\Lambda$	$\pi\Sigma$	$\eta\Sigma$	$\bar{K}\Delta$	$\pi\Sigma^*$
PW	S	S	S	S	D	D
LO	45(8)	51(7)	6.2(5.3)	14(2)	0.07(0.04)	0.5(0.3)
NLO	30(34)	38(12)	4.2(7.6)	53(28)	0.4(0.2)	0.4(0.5)
Exp	27.5(21)		4.4(4.4)	38.5(28)		

	$\Lambda(1405)$	$\Lambda(1520)$	
	$\pi\Sigma$	$\bar{K}N$	$\pi\Sigma$
PW	S	D	D
LO	50(19)	2.7(0.4)	8.2(1.3)
NLO	50(9)	6.7(1.1)	6.9(1.8)
Exp	50(5)	7(0.5)	6.5(0.5)

	$\Sigma(1775)$					
	$\bar{K}N$	$\pi\Lambda$	$\pi\Sigma$	$\eta\Sigma$	$\bar{K}\Delta$	$\pi\Sigma^*$
PW	D	D	D	D	D	D
LO	39(3)	27(3)	3.0(1.2)	0.08(0.01)	1.6(0.2)	7(1)
NLO	55(12)	14(4)	0.6(0.8)	0.22(0.06)	3.9(0.8)	7.4(2.3)
Exp	48(7)	20.4(4.4)	4.2(2)			12(2.8)

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	$\Xi(1820)$				
	$\pi\Xi^*$		$\bar{K}\Lambda$	$\bar{K}\Sigma$	$\pi\Xi$
PW	S	D	D	D	D
LO	2.3(0.6)	2.6(0.3)	10(1)	14(1)	4.2(0.9)
NLO	2.4(2.2)	3.2(0.6)	18(3)	29(4)	0.3(0.6)
Exp					

$$\chi^2_{\rm dof} \sim 1.2$$

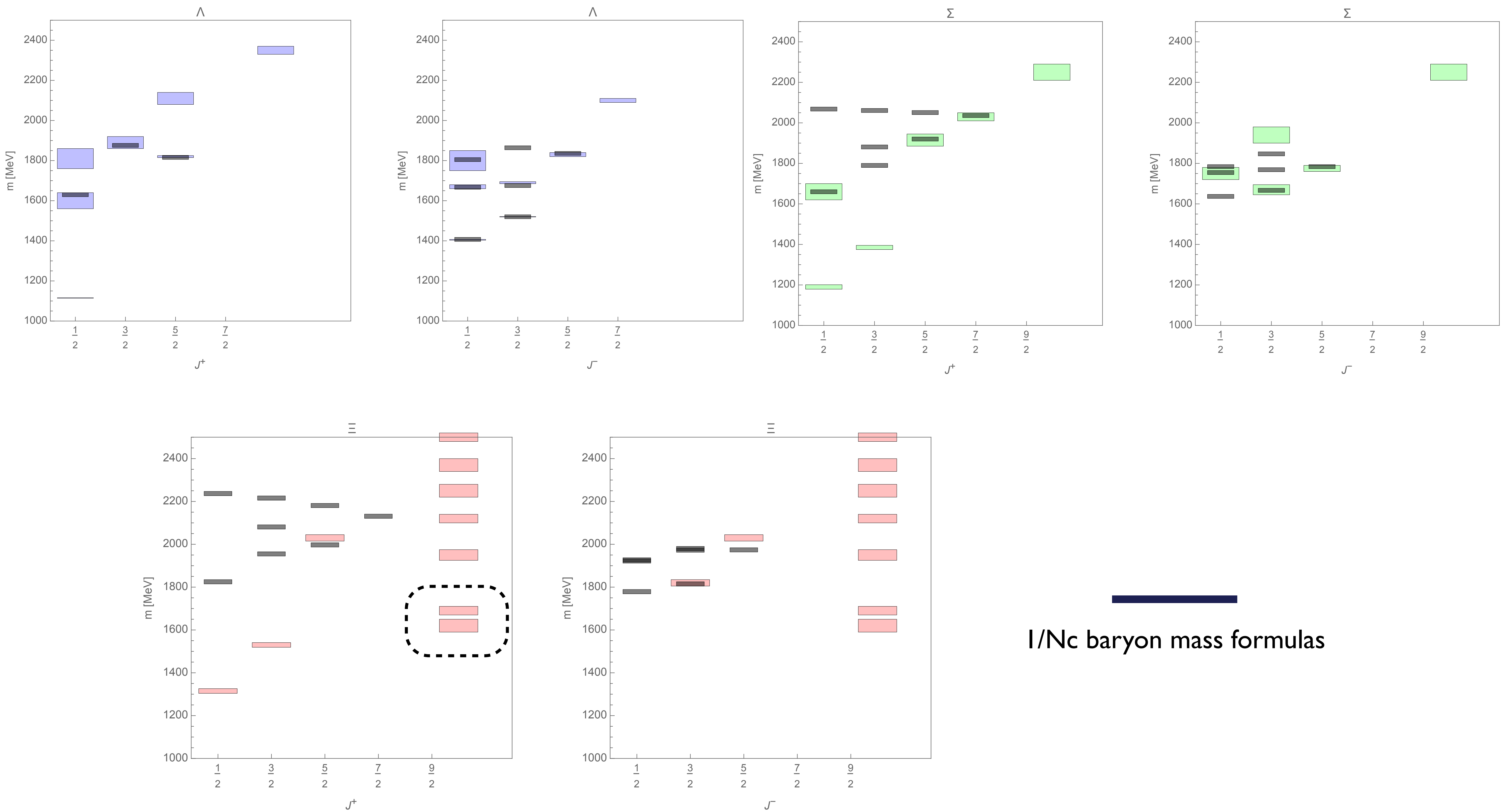
S-wave: 14 PDG PW inputs fitted with 7 parameters
D-wave: 25 " 8 "

PW predictions for unobserved states in 70-plet are possible with these same calculations: to be done

Comments

- K_L beam opens renewed opportunities to research hyperon physics at JLab.
- Predictions grounded on symmetries can be made once a sufficient number of states in a given multiplet can be identified. Numerous are already available.
- Interesting puzzles exist for PDG listed excited hyperons which do not fit into any of the low lying excited multiplets: they need to be further revisited and investigated.
- Excited Ξs are very poorly known. Establishing and discovering new states is important for establishing the multiplet structure of excited baryons in particular.
- An upcoming source of predictions to be watched is Lattice QCD. (D. Richards talk)

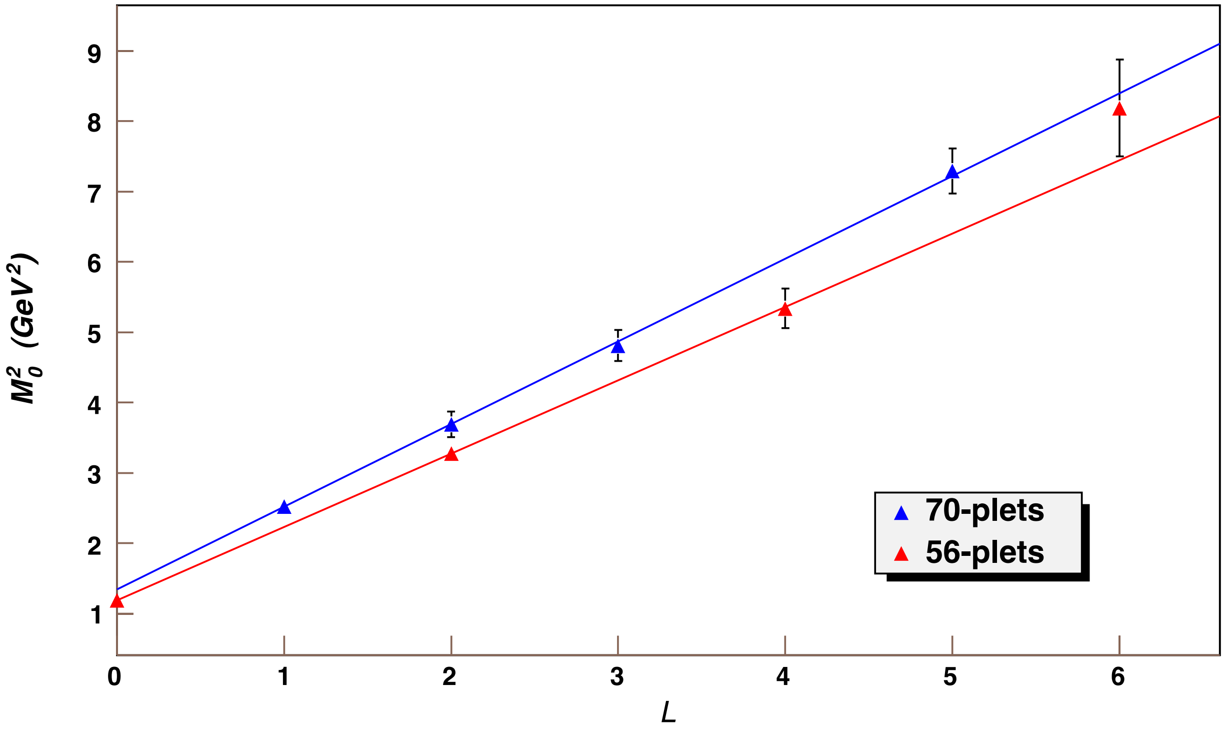
Present status of excited hyperons (PDG)



Chew-Frautschi for spin-flavor singlet piece of baryon masses

$$[\mathbf{56}, 0^+]_{GS},\ [\mathbf{56}, (2^+, 4^+, 6^+)],\ [\mathbf{70}, (1^-, 2^+, 3^-, 5^-)]$$

+ a grain of salt



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- $M_0^2[\mathbf{56}, \ell] = [(1.18 \pm 0.003) + (1.05 \pm 0.01)\,\ell]\ \mathrm{GeV}^2$
- $M_0^2[\mathbf{70}, \ell] = [(1.13 \pm 0.02) + (1.18 \pm 0.02)\,\ell]\ \mathrm{GeV}^2$
- $(M_0[\mathbf{70}, \ell] - M_0[\mathbf{56}, \ell])^2 \simeq (5.7 + 4.2\,\ell) \times 10^{-4}\ \mathrm{GeV}^2$
- Splitting between trajectories $\mathcal{O}(N_c^0)$: due to exchange interaction. In magnitude smaller than expected.
- Regge trajectories with physical masses include contributions which do not have linear behavior.
- Strong indication of small **56**-**70** configuration mixings and good approximate $O(3)$ symmetry