Light Baryon Resonances: Perspectives

Baryon spectroscopy continues to motivate an extensive experimental program, with most studies focused on the missing resonance problem. While many states predicted by conventional quark models and lattice QCD have yet to be seen [1], other states, such as pentaquarks and hybrids, are also interesting, as they offer potentially new information on the dynamics of confinement. Given the underpopulation of conventional 3-quark states, it is difficult to identify these unconventional states.

The problem of nucleon resonances N' with masses below the Δ–isobar and its unitarity partners was considered in Ref. [2]. For now, let us restrict ourselves to the simplest hypothesis of N' being a member of a unitary octet, and tentatively discuss other possible members of the ½⁻ octet (Fig. 1). Notes that there are no predictions of such states within CQM [3] and LQCD [4].

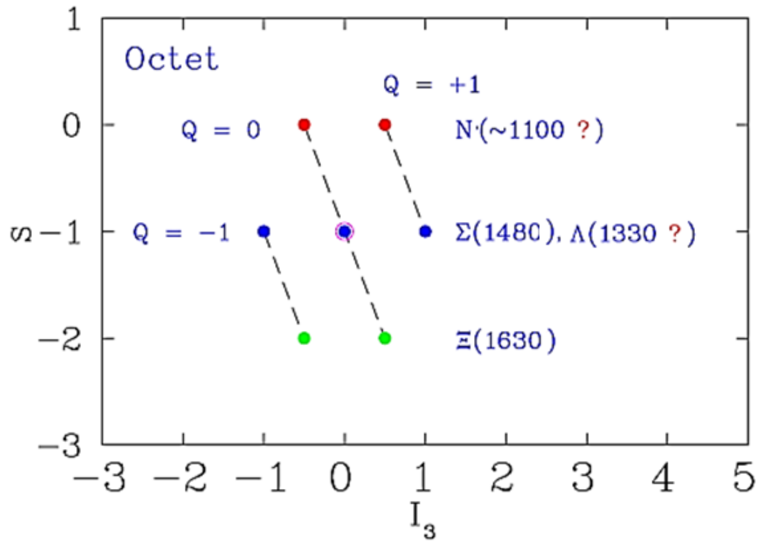

Fig. 1. Tentative unitary octet with N' [2].

Since review [2], two solid experimental evidences for $\Sigma(1480)$ came from the ANKE Collaboration [5] and for $\Xi(1620)$ came from the BELLE Collaboration [6]. Meanwhile, some evidence for $\Xi(1620)$ was observed by the CLAS Collaboration as well [7]. The Gell-Mann-Okubo mass formula assign $J^P=1/2^-$ with masses of $\Lambda(1330)$ (rather old JINR HBC results [8], while CLAS did not have good statistics to validate this case [9]), $\Sigma(1480)$, and $\Xi(1620)$ gives for N' just the mass of about 1100 MeV [1]. Notes that mixing is able to shift some masses.

Present information on this tentative unitary octet is summarized in Table 1. It reported, in particular, decay modes and values of hadronic production cross sections. Notes that the corresponding cross sections for photoproduction may be estimated as multiplied by the factor α/π, while for electroproduction, the factor should be of the order of $(\alpha/\pi)^2$.

Table 2. summarizes and compares existing bounds for various quantities describing interactions (or couplings) of the N' with familiar hadrons. Notes that the modified PWA suggested the following parameters for S_{11} N': M = 1145 MeV and Γ = 50 keV [1].

Table 1. Possible unitary octet with N' [2].

State	Mass (MeV)	Width (MeV)	Decay Modes	Hadron Production Xsections
N′	∼1100 ?	<0.05	Nγ ?	$< 10^{-4}$ of "normal"
Λ	1330 ?		Λγ	$\sim 10\mu b$
Σ	1480	30-80 ?	Λπ, Σπ, N$\bar{K}$	$\sim 1\mu b$
Ξ	1630	20-50 ?	Ξπ	$\sim 1\mu b$

Table 2. Boundaries for N' below and above πN threshold [2].

Interactions	Below πN threshold	Above πN threshold
Purely Hadronic	$\frac{g^2_{\pi NN'}}{g^2_{\pi NN}} < 10^{-2}$	$\Gamma_{N'} < 50$ keV
	$\frac{\sigma(pp\to nX^{++})}{\sigma(pn\to np)} < 10^{-7}$ [4]	$\left[\frac{\Gamma_{N'}}{\Gamma_\Delta} < 4\times 10^{-4}\right]$
	$\frac{\sigma(pp\to \pi^+ pX^0)}{\sigma(pp\to \pi^+ pn)} \sim 10^{-3} - 10^{-4}$ [32]	
Hadronic and EM	$\frac{W(\pi^- p\to n'\gamma)}{W(\pi^- p\to n\gamma)} < 8\times 10^{-5} [\sim 10^{-5}]$	
	$\Gamma_{N'\to N\gamma} < 5$ eV [6]	$\mathrm{Br}^\gamma_2\, \Gamma_{p'} < 10$ eV [6]
	$\frac{Y(ep\to e'\pi^+X^0)}{Y(ep\to e'\pi^+ n)} < 10^{-4}$ [10,11]	$\left[\frac{Br_\gamma \Gamma_{p'}}{Br_\gamma \Gamma_\Delta} < 2.8\times 10^{-3}\right]$
	$\frac{Y(ed\to e' pX^0)}{Y(ed\to e' pn)} < 10^{-4}$ [11]	

References

[1] M. Tanabashi *et al.* (Particle Data Group), Phys. Rev. D **98**, 030001 (2018).
[2] Ya. I. Azimov, R. A. Arndt, I. I. Strakovsky, and R. L. Workman, Phys. Rev. C **68**, 045204 (2003).
[3] S. Capstick and N. Isgur, Phys Rev D **34**, 2809 (1986)
[4] R. G. Edwards *et al* (Hadron Spectrum Collaboration), Phys Rev D **87**, 054506 (2013).
[5] I. Zychor *et al.* (ANKE Collaboration), Phys. Rev. Lett. **96,** 012002 (2006).
[6] M. Sumihama *et al.* (Belle Collaboration), Phys. Rev. Lett. **122,** 072501 (2019).
[7] L. Guo *et al.* (CLAS Collaboration), Phys. Rev. C **76**, 025208 (2007).
[8] N. P. Bogachev *et al.*, JETP Lett. **10**, 105 (1969).
[9] S. Taylor, Ph.D. Thesis, Rice U., May 2000.

Igor Strakovsky, 06/23/2019