Brief Review of Light, Strange Baryon under Non-relativistic Quark Model

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Introduction

The prime goal of hadron spectroscopy is to understand the quark dynamics so as to know underlying degrees of freedom responsible for the observed proerties of a hadron. The study of mass spectra through theoretical, phenomenological and experimental models has been undertaken. The light, strange baryon sector has been studied for years however with limited information especially for strange baryons. Precisely, Ξ and Ω are the least known spectra, also in Λ and Σ baryon spectra, a few states need attention towards their nature [1, 2].

The first and foremost members of octet and decuplet families, nucleon N and Δ baryon have always been of interest. Various decay of strange as well as other heavy baryons are ultimately reaching to these light baryons. In case of strange baryons, most of the data have been based from earlier studies from bubble chamber for K^-p reactions. However, few experiments are now directed towards the strange sector.

This review makes an attempt to compare a number of models namely relativistic approach [4], quark-diquark system, QCD SUM Rules, light-front model, Lattice QCD, Faddeev approach, Skyrme model, Regge phenomenology [5] and so on. As not a model is precisely predicting all the observed experimental states, a wide comparison is expected to take us more towards the understanding and basis of different approaches.

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Theoretical Framework

The non-relativistic model used here is hypercentral Constituent Quark Model (hCQM). The model itself suggets that the potential to be chosen should be hypercentral i.e. depending only on hyperradius x. The hyperradius x depends at the same time on all the three constituent coordinates, therefore an hypercentral potential is not a pure two body interaction but can also contain three body terms. The Jacobi co-ordinates are used for the three body systems.The space part of the three quark wave function can be expanded in the hyperspherical harmonics basis and the Schrodinger equation becomes a set of coupled differential equations [6–8].

The Hamiltonian then becomes,

$$H = \frac{P^2}{2m} + V^0(x) + V_{SD}(x) \tag{1}$$

where $m = \frac{2m_\rho m_\lambda}{m_\rho + m_\lambda}$ is the reduced mass. The potential is solely hyperradius dependent. So, it consists of a Coulomb-like term and a linear term acting as confining part. The V_{SD} being the spin-dependent term takes care of the hyperfine splitting. In addition, here a first-order correction $\frac{1}{m}$ is incorporated.

$$V^1(x) = -C_F C_A \frac{\alpha_s^2}{4x^2} \tag{2}$$

where $C_F = \frac{2}{3}$ and $C_A = 3$ are Casimir elements of fundamental and adjoint representation.

Results and Discussion

Above approach has been a tool to obtain a number of radial and orbital resonance masses for octet and decuplet baryons from S to G-wave states. This holds a great deal when it

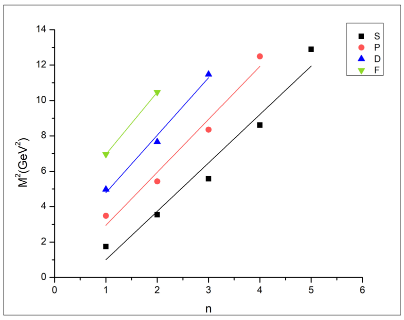

FIG. 1: Regge Trajectory Ξ for $n \to M^2$

comes to experimental findings as strange sector is scarcely known. Also, some properties such as Regge trajectories, baryon magnetic moment, decay width are explored based on the obtained spectra. To list a few states from N to Ω in table below. Detailed results shall be presented later. Also, figure 1 shows one such Regge trajectory drawn for Ξ baryon for $n \to M^2$ for linear fitting.

TABLE I: Resonances masses for light, strange baryon (in MeV).

Baryon	State	J^P	M	PDG[1]	Status
N	1S	$\frac{1}{2}^+$	938	938	****
	1P	$\frac{1}{2}^-$	1520	1515-1545	****
	1D	$\frac{5}{2}^+$	1722	1680-1690	****
Δ	1P	$\frac{1}{2}^-$	1625	1590-1630	****
	1D	$\frac{1}{2}^+$	1905	1850-1950	****
	1F	$\frac{7}{2}^-$	2037	2150-2250	***
Λ	1S	$\frac{1}{2}^+$	1115	1115	****
	$1^2P_{1/2}$	$\frac{1}{2}^-$	1558		
Ω	1S	$\frac{3}{2}^+$	1672	1672	****
	$1^2P_{1/2}$	$\frac{1}{2}^-$	1996		

Conclusion

The non-relativistic constituent quark model with potential depending on hypercentral one has been used with the aim of obtaining all possible spin-parity states of light, strange baryons of octet and decuplet family. The study with first order correction in mass gave reasonable results but the ordering of spin-parity could not be corrected. The study has obtained a number of resonance states upto higher J values which is expected to be of great help in upcoming as well as ongoing experiments like PANDA [9, 10] and BESIII [11] respectively. The comparison is not just with the experimental data but also with a wide range of theoretical and phenomenological approaches. This shall allow to reach the possible modifications of any approach to better interpret the internal quark dynamics. The higher strangeness baryons with least information with some puzzling states are expected to get a new insight to be looked for in experiments through this spectra.

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