BARYONS AND EXOTICS MASSES IN QUASI PARTICLE APPROACH

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Introduction

Baryon in the conventional quark model are color singlets composed of three quarks. Gell-Mann[1] himself suggested the idea that q-q bound states or diquarks can be formed within the hadron. The diquark picture allow us to look at a baryon as being composed of a diquark and quark whereas multiquarks baryons like penta quarks(qqqqq) to be composed of two diquarks and one antiquark. In this present article we have investigated the masses of the Baryons, Doubly Heavy Baryons and heavy exotic Baryons (pentaquarks) with diquark-quark and diquark-diquark-anti quark configuration for the baryons and pentaquarks respectively considering diquark as fundamental entity.

Diquark in Quasi particle approach:

Recently we have suggested a quasi particle model [2] for diquark. In this model two quarks are assumed to be correlated to form a low energy configuration forming a diquark and behaving like a quasi particle in an analogy with the electron behaving as a quasi particle in the crystal lattice. A quasi particle is a low-lying excitation whose motion is modified by the interactions within the system. An electron in a crystal is subjected to two types of forces, namely, the effect of the crystal field (∇V) and an external force (F), which accelerates the electron. Under the influence of these two forces, an electron in a crystal behaves like a quasi particle whose effective mass m* reflects the inertia of electrons which are already in a crystal field. We have proposed a similar type of picture for the diquark as a quasi particle inside a nucleon. We have assumed that the diquark is a fundamental entity behaving like independent body, which is under the influence of two types of forces. One is due to the background meson cloud which is represented by potential $V = -\alpha/r$, where $\alpha = (2/3)\ \alpha_s$ being the strong coupling constant, and this potential resembles the crystal field on a crystal electron. On the other hand for the external force we have considered an average force F = -ar, where 'a' is a suitable constant, which is of confinement type. It has been assumed that under the influence of these two types of interactions the diquark behaves like a quasi particle, a low lying excited state simulating many body interactions within the system and its mass gets modified. We have obtained : $m + m'/ m(D) = 1+\alpha/2ar^{2}$,where r is the radius parameter of diquark, m and m' are constituent quark masses and m(D) is the effective mass of diquark. The mass of diquark can be computed from the above expression. It is well known that in the ensemble of such an ideal gas of quasi particles, the particles move independently and their energies are simply additive [3] where their effective masses characterize the dynamic properties of the system. We have estimated the diquark mass in the framework of the quasi-particle model in effective mass approach and the masses of the baryons, heavy baryons and exotics have been estimated using the concept of additive energy of the quasi particles. The approach is naïve and simple. The results that obtained are displayed in Table-1.

Formulation:

In the current description of quasi particle of diquark the masses of the baryons and exotics can be computed considering the low lying excitation and regarded as separate elementary entities, behaving like a scalar boson analogous to quasi particle. Therefore in an ideal gas of quasi particle the energy of the diquark, baryons and heavy exotics are simply additive[3] so that .$M_B = M_D + M_q$; $M_{exotic} = M_D + M_{D+} M_q$ The results obtained are quite encouraging and are found to be in good agreement with existing theoretical predictions and available experimental data. The results are shown in Table-2, Table-3 and in Table-4.

Tables: Table 1: Diquark Masses in quasi particle approach.

Diquark	Mass (in GeV)
[ud]	0.590
[us]	0.674
[ss]	0.899
[uc],[dc]	1.519
[sc]	1.626
[sb]	2.979
[ub],[db]	3.165

Table 2: Baryon Masses using diquark masses.

Baryons	Content	Mass	
		Our work (in GeV)	Expt.[4] (in GeV)
P	uud	0.950	0.938
n	udd	0.950	0.939
Λ^0	uds	1.130	1.115
Ξ^0	uss	1.214	1.314
Λ^+_c	udc	2.300	2.286
Ξ^+_c	usc	2.384	2.468

Table 3: Doubly Heavy Baryon Masses using diquark masses.

Doubly Heavy Baryon	Content	Mass	
		Our work (in GeV)	Expt. (inGeV)
Ξ^{++}_{cc}	ucc	3.229	-
Ξ^+_{cc}	dcc	3.229	3.5187±0.0017 [5]; 3.082±0.0018 ±0.0015[6]
Ω^+_{cc}	scc	3.336	-
Ξ^0_{bb}	ubb	8.215	-
Ξ^-_{bb}	dbb	8.215	-
Ω^+_{bb}	sbb	8.029	-
Ξ^+_{cb}	ucb	6.569	-
Ξ^0_{cb}	dcb	6.569	-
Ω^0_{cb}	scb	5.676	-

and

Table 4: Masses of Heavy Pentaquark using diquark masses.

Heavy Pentaquarks	Content	Mass		
		Our work (in GeV)	Expt. (in GeV)	JW model [7] (in GeV)
Θ_c^0	[ud][ud]c	2.890	3.009±0.003±0.005	2.710
N_c^0	[ud][us]c	2.974	-	2.870
Ξ^0_c	[us][us]c	3.058	-	3.135
Θ_b^0	[ud][ud]b	6.230	-	6.050
N_b^0	[ud][us]b	6.314	-	6.210
Ξ^0_b	[us][us]b	6.398	-	6.351

Conclusion:

The quasi particle model of diquark is found to be quite successful in reproducing the masses reasonably. It is interesting to note that the mass of the particle are obtained by simply adding the diquark and quark mass which indicates that the diquark is behaving as an independent entity like phonon without any interaction with the other. It may be suggested that the background may behave like a super fluid which favours the formation of the diquark.

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