Masses and decay properties of Σ_c baryons

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Introduction

Charmed baryons with at least one c quark have the masses ranging from 2300 to 2700 MeV. Recent experimental results from BABAR, CLEO, DELPHI, BELLE and CDF collaborations have encouraged theoreticians to pursue study of masses and magnetic moments of these systems[1]. The study of their decay modes and magnetic moments are crucial to understand the dynamics of these systems as c quark is considered as a connecting flavour between heavy and light flavour sectors. We study the masses and decay properties of Σ_c baryons using the extended relativistic confinement scheme based on harmonic approximation with Lorentz scalar and vector potential. The residual two body Coulombic interaction and spin hyperfine interactions of confined one gluon exchange potential are included perturbatively to compute masses of the baryons [2–5]. The transition magnetic moments of baryons using the spin-flavoured wave function of the constituent quarks and their effective masses within the baryons are also computed. We compare the computed results with the theoretical predictions as well as available experimental observations.

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Formalism

We compute the mass spectra in the formalism of extended relativistic harmonic confinement model (ERHM), in which the confinement of quarks are assumed to be of the form Lorentz scalar along with the vector harmonic oscillator mean field potential of the form [2–5],

$$V_{conf} = \frac{1}{2}(1+\gamma_0)A^2r^2 \qquad (1)$$

Here A is the model parameter and γ_0 is the Dirac matrix.

The masses are computed by solving Dirac equation employing the nonrelativistic reduction technique. The octat and decuplet masses of the baryons are computed by employing the confined one gluon exchange potential perturbatively.

We also compute the transition magnetic moment considering the mass of bound quark inside the baryon as effective mass that arises out of quantum fluctuations in the baryon dynamics [6]. The transition magnetic moments are computed using

$$\mu_{B^*\to B} = \langle B|\hat{\mu}_{B^*z}|B^*\rangle \qquad (2)$$

where B^* and B are the parent and daughter baryon respectively [7–10]. The parameters used for this compitations are as follows: confinement mean field parameter $A = 2166$ MeV$^{3/2}$ and quark masses $m_u = 340$ MeV, $m_d = 343$ MeV, $m_c = 1479$ MeV.

TABLE I: Masses of Σ_c Baryons in MeV

state	mass	[11]	[12]	[13]	[14]	PDG[1]
Σ_c^{++}	2453.21	2454	2454	–	–	2453.97 ± 0.14
Σ_c^{*++}	2513.51	2530	2492	–	–	2518.41
Σ_c^{+}	2455.67	2452	2459	–	–	2452.9 ± 0.40
Σ_c^{*+}	2515.5	2501	2497	–	–	2517.5 ± 2.3
Σ_c^{0}	2457.28	2453	–	2443	2460	2453.75 ± 0.14
Σ_c^{*0}	2518.43	2529	–	2519	2523	2518.48 ± 0.20

TABLE II: Transition magnetic moment of Σ_c baryons in μ_N

transition	$\lvert\mu_{B'\to B}\rvert$	[15]	[16]	[17]	[18, 19]
$\Sigma_c^{*++} \to \Sigma_c^{++}$	1.020	1.37	1.19	1.398	0.998
$\Sigma_c^{*+} \to \Sigma_c^{+}$	0.01	0.003	0.04	0.105	0.009
$\Sigma_c^{*0} \to \Sigma_c^{0}$	1.04	1.48	1.11	1.187	1.022

Results and Discussion

The computed masses are tabulated in Table I. The transition magnetic moments (Tab. II) are also computed without any additional parameters, so they are absolute predictions considering the effective masses of quarks inside the baryons. We also compare with other theoretical and experimental results and it is observed to be matching well. Till the date the detailed description of decay of these baryons still not known experimentally, the present calculations can be interesting as they are matching well with the other theoretical models. New experimental data from now operational experimental facilities like LHCb, BESIII and B factories as well as upcoming facilities like $\overline{\text{P}}$ANDA and J-Park are expected probe the dynamics of the charmed baryonic systems. The other weak decay properties of these baryon also the spectroscopy of doubly heavy baryons are underway.

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