Regge trajectories in the B meson

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Introduction

Regge trajectories have recently gained interest due to many new experimental meson states being observed. They play a vital role to identify new meson excited states as well as to provide information about the quantum numbers of that particular state. In this article we investigate the Regge trajectories of the B mesons in the potential model framework.

Masses of the B meson

The mass spectra of the B meson are generated within the framework of a potential model (Coulomb plus linear) with the help of a variational approach. The Hamiltonian for the system is[1]

$$H = \sqrt{\mathbf{p}^2 + m_Q^2} + \sqrt{\mathbf{p}^2 + m_{\bar{Q}}^2} + V(\mathbf{r}), \quad (1)$$

$$V(\mathbf{r}) = -\frac{4\alpha_S}{3r} + Ar + V_0; \quad (2)$$

here, $m_Q(m_{\bar{Q}})$ is the quark(anti-quark) mass. α_S is the strong running coupling constant and A is the string tension, V_0 is the potential constant.

We make use of Gaussian trial wavefunction as well as the usual spin-spin, spin-orbit and tensor interactions to estimate the excited state masses. The details of the calculations can be found in ref [2].

Results

In figures, solid triangles are model masses whereas experimentally available masses(taken from PDG[3]) are represented by hollow squares. The Regge trajectories for the $\left(J \to M^2\right)$ planes for the natural and unnatural parity are plotted in gifures (1) and (2) respectively. The Regge trajectories for $n_r = n - 1$ (n=principal quantum number) in the (n_r, M^2) plane are plotted in Figure (3).

The B meson Regge trajectories identify new excited states and support assignment for meson: $B_J(5970)$ to 2^3S_1 state and $J^P = 1^-$. From Figs. (1-3), it can be observed that the experimental states fall nicely on the straight line without deviation.

Parity	Trajectory	$\alpha(GeV^{-2})$	α_0
	Parent	$0.219^{\pm 0.029}$	$-6.152^{\pm 0.948}$
Unnatural	FD	$0.245^{\pm 0.016}$	$-8.660^{\pm 0.617}$
	Parent	$0.237^{\pm 0.028}$	$-5.796^{\pm 0.904}$
Natural	FD	$0.300^{\pm 0.024}$	$-9.648^{\pm 0.093}$

TABLE I: Slopes and intercepts of the (J, M^2) Regge trajectories of bottom meson. FD=First daughter,

State	J^P	$\beta(GeV^{-2})$	β_0
$^1S_0$	0^-	0.165 ± 0.010	-4.670 ± 0.039
$^3S_1$	1^-	0.171 ± 0.009	-4.935 ± 0.344
$^3P_0$	0^+	0.1748	-5.7571
P_1	1^+	0.173	-5.776
P_1'	1^+	0.176	-5.900
$^3P_2$	2^+	0.1751	-5.830
$^3D_1$	1^-	0.194	-7.250
D_2	2^-	0.194	-7.283
D_2'	2^-	0.189	-6.967
$^3D_3$	3^-	0.190	-6.989

TABLE II: Slopes and intercepts for the (n_r, M^2) Regge trajectories of bottom meson.

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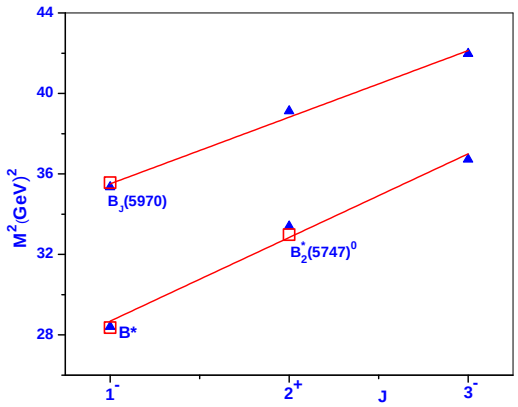

FIG. 1: The $(M^2 \to J)$ Regge trajectories for the bottom meson with natural parity.

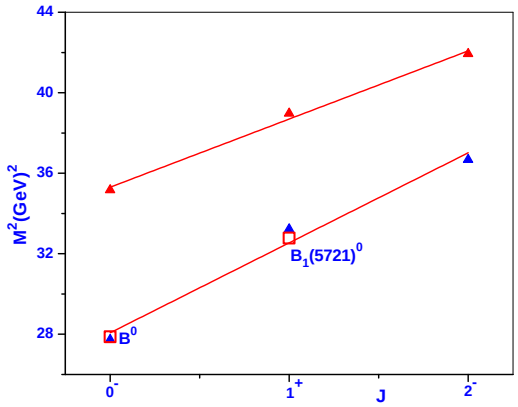

FIG. 2: The $(M^2 \to J)$ Regge trajectories for the bottom meson with unnatural parity.

The following definitions are used to calculate the χ^2 fitted slopes (α, β) and the intercepts (α_0, β_0) [4].

$$J = \alpha M^2 + \alpha_0. \tag{3}$$

$$n_r = \beta M^2 + \beta_0. \tag{4}$$

The slopes and intercepts for the $(J \to M^2)$ $(n_r \to M^2)$ Regge trajectories are given in tables I and II respectively.

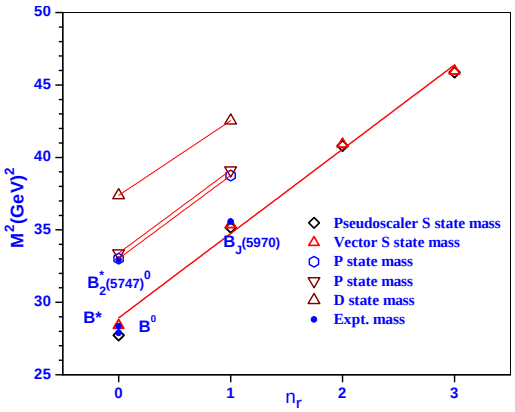

FIG. 3: The $(M^2 \to n_r)$ Regge trajectories for the pseudoscalar and vector S state, excited P and D state masses of the bottom meson.

References

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