D_{s0} and B_{s0} mesons in hot and dense symmetric nuclear medium

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Introduction

The main aim of the high energy physicist, is to understand the QCD phase diagram and to create a road map between QGP phase to hadronic phase. One unique way is to understand the nucleons in terms of quarks and to achieve this goal, we study the properties of mesons in the medium and then, compare them with the properties of mesons in the vacuum. In the present paper, we investigate the effect of density and temperature of the medium on the shift in masses and decay constants of scalar D_{s0} and B_{s0} mesons in the hot and dense symmetric nuclear medium, using chiral SU(3) model and QCD sum rules approach. If the masses of $D_{s0}(B_{s0})$ mesons decrease in the medium then, higher charmonium(bottomonium) states produced in the heavy ion collision(HIC) experiments may decay to these mesons, instead of $J/\psi(\Upsilon)$ state. This point is important, because the J/ψ suppression is considered as an important signal for production of Quark Gluon Plasma in HIC experiments. The study of in-medium masses may also be important to understand the nucleon - meson bound states. The results of the present work, may be used to understand the various outcomes of the HIC experiments like CBM and Panda under the FAIR Facility, at Darmstadt Germany.

Methodology

Chiral SU(3) model is an effective theory, which works in the non-perturbative regime. It includes an effective Lagrangian density, which describes kinetic energy terms, baryon meson interactions, self interactions of scalar mesons, vector mesons, symmetry breaking terms and also the scale invariance breaking logarithmic potential terms. Using mean field theory, we solve this Lagrangian density to find the coupled equations of motion for the scalar fields σ, ζ and scalar dialaton field χ. We solve these equations to calculate the medium modified scalar fields. Using broken scale invariance property of QCD, we represent the gluon condensate, whereas using explicit symmetry breaking term, we express quark condensate, in terms of these medium modified scalar and dialaton fields. Further, we use these medium modified quark and gluon condensates in the QCD sum rules to calculate the in-medium masses and decay constants of D_{s0} and B_{s0} mesons. In QCD sum rules, we start with the two point correlation function which, we can expand in three terms vacuum part, medium depended part and pion bath term using operator product expansion(OPE). In the present work, we neglect the pion bath term and take the temperature dependence on the masses and decay constants, through the temperature dependence of the scalar and dialaton fields[1].

Results and discussion

The values of masses, decay constants and threshold parameters of $D_{s0}(B_{s0})$ mesons are taken as 2.317(5.850), 0.20(0.23) GeV, and 7.4(40) GeV^2, respectively [2]. Nuclear matter saturation density is taken as 0.15 fm^{-3}. Average value of coupling constant is approximated as 6.74. We take the same Borel window for mass and decay constant as (5-8), and (28-32) GeV^2 for D_{s0} and B_{s0} mesons, respectively. Fig.1 shows the shift in masses(subplot (a) - (b)), and decay constants(subplot(c)-(d)) of the D_{s0} and B_{s0} mesons, respectively. We observe an enhancement in the masses of D_{s0}

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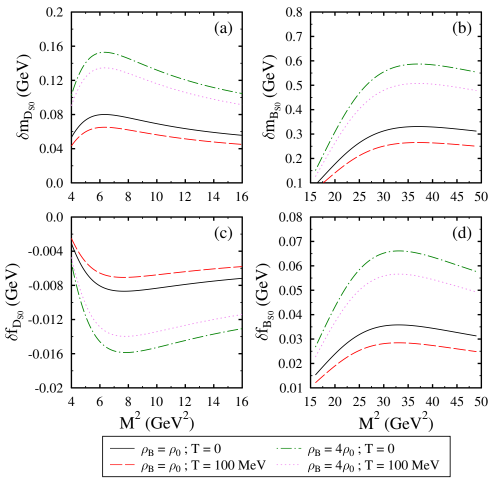

FIG. 1: (Color Online) We represents the effect of temperature and density on the shift in masses and decay constants of D_{s0} and B_{s0} mesons as a function of square of Borel mass parameter, M^2.

and B_{s0} in the nuclear medium. This enhancement is more in the high dense medium than in the low dense medium, whereas the values of masses of D_{s0} and B_{s0} mesons decrease as we move from zero temperature to finite temperature medium. This indicates a difficulty, in the formation of bound states of D_{s0} and B_{s0} mesons with nucleons. In addition to this, as the masses of D_{s0} and B_{s0} mesons increases in the medium hence, these mesons may not cause the J/ψ and Υ suppression in the HIC experiments. Further, we observe a negative(positive) shift in decay constants of $D_{s0}(B_{s0})$ mesons. We investigate that, the shift increase(decrease) with the increase(increase) in the density(temperature) of the medium. We have given numerical data in the Table I. In past [1], using chiral SU(3) model and QCD sum rules, the shift in masses of $D^{*+}(D^{*0})$ and $B^{*+}(B^{*0})$ mesons was observed to be -64(-92), and -443(-312) MeV, at nuclear saturation density and zero temperature, in hot and asymmetric hadronic medium. Using QCD sum rules, the shift in masses and decay constants of scalar $D(B)$ mesons had also been observed to be 54(209), and 7(39) MeV, at nuclear saturation density, zero temperature symmetric nuclear medium [3]. Using chiral SU(3) model and QCD sum rules we observed a negative decay shift of D meson in nuclear medium [4]. We can see that the presence of strange quark, change the mass and decay shift of $D_{s0}(B_{s0})$ mesons to 80(330), and -8(36) MeV respectively, at nuclear saturation density and zero temperature symmetric nuclear medium.

TABLE I: We enlist the numerical data(in unit of MeV) of the shift in masses and decay constants of D_{s0} and B_{s0} mesons for two values of density ρ_B=ρ_0, ρ_B=4ρ_0, and for each of these two values we represents the data for two values of temperature, T = 0 and 100 MeV.

	$\rho_B = \rho_0$		$\rho_B = 4\rho_0$	
	T = 0	T=100	T = 0	T=100
$\delta m_{D_{s0}}$	80	65	152	134
$\delta m_{B_{s0}}$	330	265	587	506
$\delta f_{D_{s0}}$	-8	-7	-15	-14
$\delta f_{B_{s0}}$	36	28	66	56

Conclusion

We observed a positive(positive) and negative(positive) shift in mass and decay constant of the $D_{s0}(B_{s0})$ mesons in hot and dense symmetric nuclear medium. Because of the enhancement in the masses, $D_{s0}(B_{s0})$ mesons may facilitate the production of $J/\psi(\Upsilon)$ states, which can be verified from the outcomes of the future HIC experiments like CBM and Panda at GSI, Germany.

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