B_c mesons in the deconfined phase

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Overview

Introduction

Early production of heavy quarkonia and their survival while crossing the deconfined medium in relativistic heavy ion collisions.

Enhacement of the B_c production in A-A collisions.

Modification of binding energy of B_c meson due to the increasing temperature of the plasma.

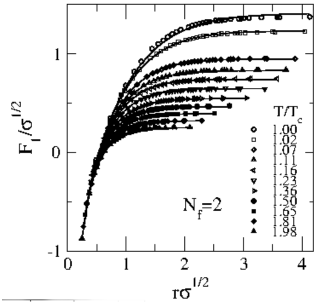
Non-relativistic potential model for a mass evaluation and energy eigenvalues.

Model

Free energy of a heavy quark-antiquark pair placed at a distance r in a thermal bath of gluons and light dynamical fermions is extracted in lattice calculations from the Polyakov loop correlation function and is fited to:

$$F(r,T) = -\frac{4}{3}\frac{\alpha(r,T)}{r}e^{m_D(T)r} + C(T).$$

The coupling α is fixed by the customary RGE, but employing a temperature dependent scale, with coefficients determined, at each temperature.



Model

The singlet internal energy is calculated

$$U = -T^2 \partial(F/T)/\partial T.$$

Heavy quarks are acting as static sources of the color field. The internal energy coincides with the potential.

$$V(r,T) = U(r,T) - U(r \to \infty, T).$$

$V(r,T)$ is then inserted into the Schrödinger equation, from which the binding energy of the different stable states and their evolution with the temperature are obtained.

Model

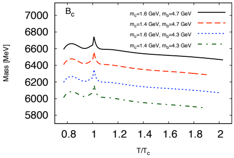
The radial wave function $R(0)$ (or of its first derivative $R'(0)$ for the P wave state) evaluated in the origin for the B_c and χ_{B_c} states respectively are used to build the spectral functions at different temperatures.
The spectral function for a generic meson channel $\sigma_M(\omega, T)$ can be written as

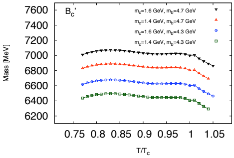
$$\sigma_M(\omega, T) = \sum_n |\langle 0 \mid j_M \mid n \rangle|^2 \delta(\omega - E_n) = \sum_n F^2_{M,n} \delta(\omega - E_n) + \theta(\omega - s_0) F^2_{M,\epsilon} ,$$

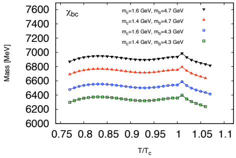
where
$F^2_{PS} = \frac{N_c}{2\pi} |R(0)|^2$ for the pseudo-scalar state and
$F^2_S = \frac{9 N_c}{2\pi m^2} |R'(0)|^2$ for the P-wave scalar state.

Results

Mass as a function of temperature of the lowest S-wave, first S-wave excited and lowest P-wave $b\bar{c}(c\bar{b})$ states as a function of temperature.





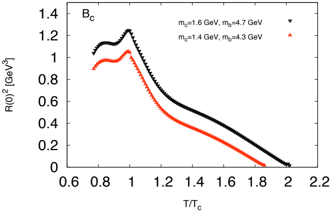


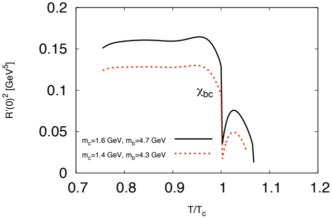
The dissociation temperatures obtained for the various states, in units of the critical temperature $T_c = 202$ MeV.

$c\bar{b}$ $b\bar{c}$	$m_c = 1.4$ GeV $m_b = 4.3$ GeV	$m_c = 1.4$ GeV $m_b = 4.7$ GeV	$m_c = 1.6$ GeV $m_b = 4.3$ GeV	$m_c = 1.6$ GeV $m_b = 4.7$ GeV
B_c	1.87	1.90	1.99	2.02
χ_{B_c}	1.05	1.05	1.06	1.06
B_c'	1.03	1.04	1.04	1.05

Results

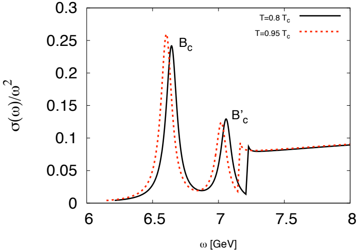
Squared value in the origin, for the $b\bar{c}$ system of the S-wave radial wave function and of the first derivative of the P-wave radial wave function, as a function of temperature.

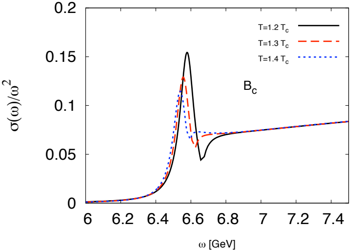




Results

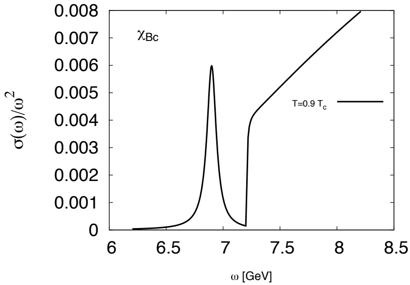
The $b\bar{c}$ S-wave channel spectral function divided by ω^2 as a function of ω at different temperatures.





Results

The $b\bar{c}$ P-wave channel spectral function divided by ω^2 as a function of ω at different temperatures.



Conclusions

We have investigated the survival above the critical temperature of a few special quarkonium states, the ones of the B_c family, with the main purpose of drawing the attention of the on-going experiments at LHC on these intriguing heavy quarkonia.

B_c mesons can survive above the temperature for deconfinement of the medium and give important information on the properties of the hot medium itself.

References

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