EPJ Web of Conferences **81**, 05008 (2014)
DOI: 10.1051/epjconf/20148105008

B_c mesons in the deconfined phase

Piotr Czerski[1,a]

[1] *The H. Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences, ul. Radzikowskiego 152, PL-31-342 Kraków, Poland*

Abstract. Charmed B mesons in a deconfined quark-gluon plasma are studied. With the introduction of the bound state of a charm and a beauty quarks at finite temperature, the behavior of the heavy quarkonium is investigated in an energy region between the ψ and the Υ states [1]. Calculations are performed within a potential model [2, 3].

1 Introduction

We investigate the early production of heavy quarkonia and their survival while crossing the deconfined medium in relativistic heavy ion collisions. The B_c formation could be favored in a nucleus-nucleus collision where many partonic (hard) scatterings can occur simultaneously and then the B_c production might be significantly enhanced. We examine the modification of binding energy of B_c meson due to the increasing temperature of the plasma.

In order to study the temperature evolution of the mass and energy eigenvalues of the B_c mesons, we employ a non-relativistic potential model.

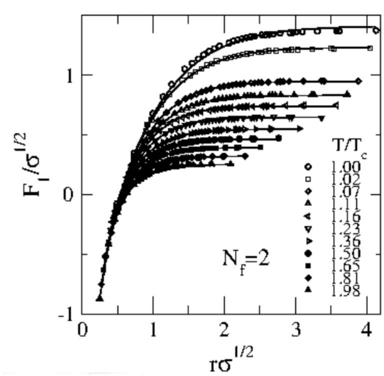

Figure 1. The colour singlet free energy $F_1(r,T)/\sqrt{\sigma}$ at different values of T/T_c as a function of the separation $r\sqrt{\sigma}$ of the $Q\bar{Q}$ sources resulting from our fitting procedure compared to the lattice data at different temperatures, with $\sqrt{\sigma} = 420$ MeV [4].

[a] e-mail: piotr.czerski@ifj.edu.pl

2 Model and Results

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:

$$F_1(r,T) = -\frac{4}{3}\frac{\alpha(r,T)}{r}e^{m_D(T)r} + C(T),$$

where the coupling α is fixed by the customary RGE, but employing a temperature dependent scale, with coefficients determined, at each temperature (see figure 1). Next, the singlet internal energy

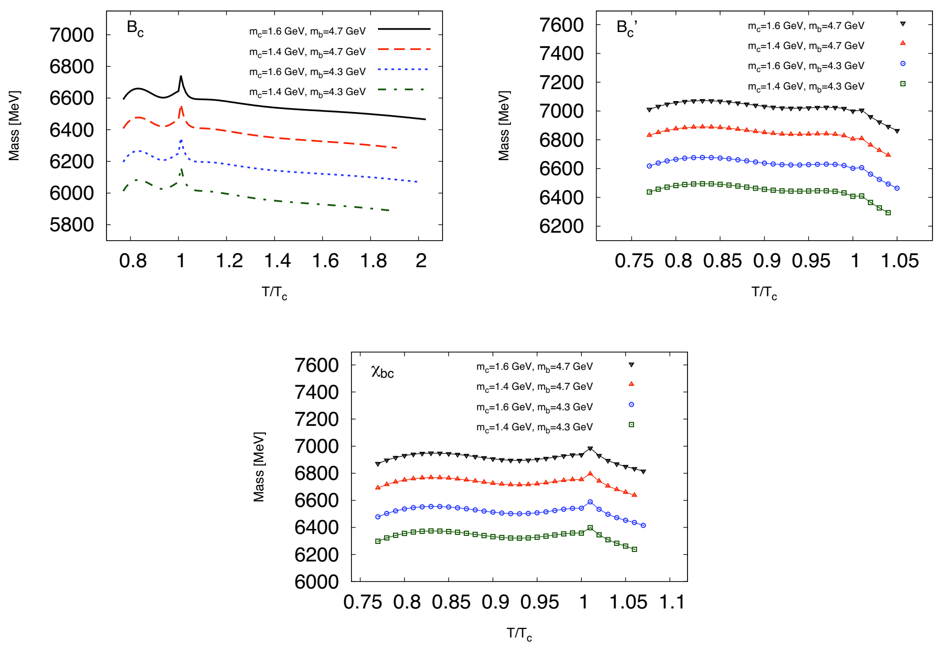

Figure 2. Mass as a function of temperature of the lowest S-wave, first S-wave excited and lowest P-wave $b\bar{c}(c\bar{b})$ states as a function of temperature.

is calculated $U = -T^2\partial(F/T)/\partial T$, since heavy quarks are acting as static sources of the color field, the internal energy coincides with the potential. $V(r,T) = U(r,T) - U(r \to \infty, T)$ and $V(r,T)$ 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, figure 2.

The radial wave function $R(0)$ (or of its first derivative $R'(0)$ for the P wave state), figure 3, 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

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

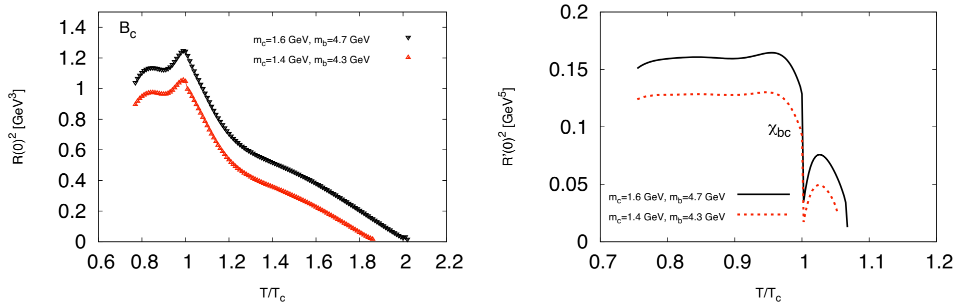

Figure 3. Squared value in the origin, for the $b\bar{c}$ system of the S-wave radial wave function and of the first derivative of the P-wave radial wave function, as a function of temperature.

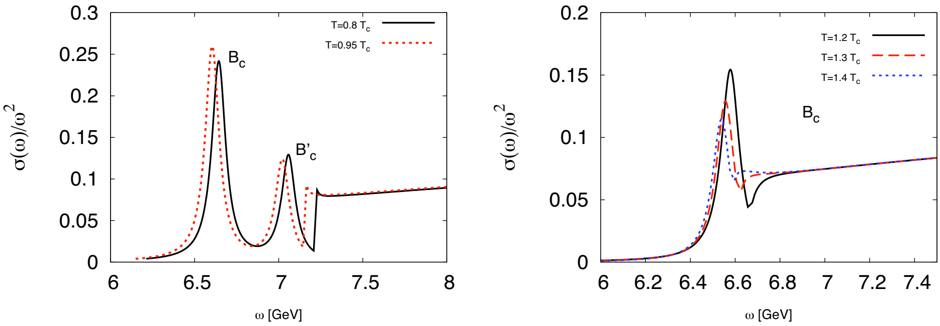

Figure 4. The $b\bar{c}$ S-wave channel spectral function divided by ω^2 as a function of ω at different temperatures.

where $F^2_{PS} = \frac{N_c}{2\pi}|R(0)|^2$ for the pseudo-scalar state, figure 4 and $F^2_S = \frac{9N_c}{2\pi m^2}|R'(0)|^2$ for the P-wave scalar state, figure 5.

Finaly, in table 1, we show the dissociation temperatures (defined as the value where the binding energy vanishes) obtained for the various states, in units of the critical temperature $T_c = 202$ MeV. From the table 1 and figure 4, which shows the evolution of the S wave spectral function with the

Table 1. The dissociation temperatures obtained for the various states, in units of $T_c = 202$ 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

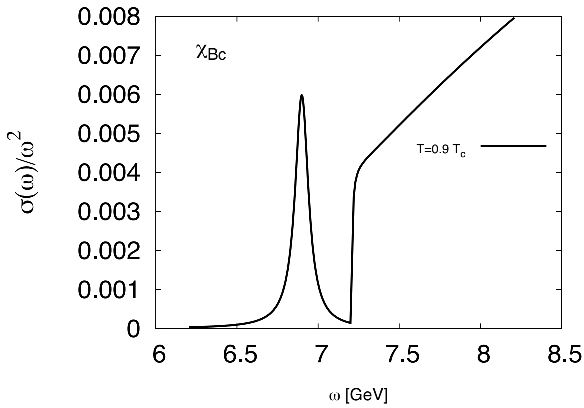

Figure 5. The $b\bar{c}$ P-wave channel spectral function divided by ω^2 as a function of ω at different temperatures.

temperature, one can see that the fundamental bound state peak survives above critical temperature (up to $\sim\ 2\ T_c$), while the excited state dissociates around T_c. In figure 5 we have the shape of the P-wave spectral function and we see that the fundamental P-wave state dissociates at $T \sim T_c$.

3 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.

Acknowledgements

I would like to thank W. Alberico, M. Nardi, C. Ratti, S. Carigniano and A. De Pace from Torino University and INFN Torino for a fruitful collaboration.

References

[1] W. M. Alberico, S. Carignano, P. Czerski, A. De Pace, M. Nardi, C. Ratti, Cent. Eur. J. Phys. **12**, 780 (2014), arXiv:1311.5733.
[2] W. M. Alberico, A. Beraudo, A. De Pace, A. Molinari, Phys. Rev. D **72**, 114011 (2005).
[3] W. M. Alberico, A. Beraudo, A. De Pace, A. Molinari, Phys. Rev. D **75**, 074009 (2007).
[4] O. Kaczmarek, F. Zantow, Phys. Rev. D 71, 114510 (2005).