Study of 1P states of Quarkonia using Quasi-Particle approach with Baryonic chemical potential

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Abstract :- We determine the properties of 1P states of Charmonium & Bottomonium in the presence of Baryonic chemical potential using Quasi particle approach. Here we employed the medium modified form of Cornell potential which has both Coulombic as well as String part. This enables us to study the properties of heavy Quarkonia even above the critical temperature. Using Quasi particle approach with Baryonic chemical potential we study the binding energy and the dissociation temperature of the 1P states of Quarkonia The mass spectra of 1P states of Quarkonia is also calculated in the presence of Baryonic chemical potential.

Introduction :- Quarkonium is flavorless meson of heavy quarks and its antiquark.J/Ψ and ϒ are the ground states of charmonium and bottomonium respectively. χ_c (3.5 GeV/c^2 and χ_b (9.8 GeV/c^2) are the excited 1P states of Quarkonium. QCD is the theory of strong interaction. In present paper we use the medium modified heavy quark Potential [1] which has Coulombic as well as Yukawa term.30% of J/Ψ yield obsrved in the collision is produced by χ_c decay. Higher excited states will desolve at smaller temperature as compare to more tightly bound ground states.I.e. χ_c will be desolve at lower temprature[3]. If the given energy density is not enough to melt the ground state , then it is sufficient to melt the the higher excited state.this fact motivate us to make special attention on excited states.

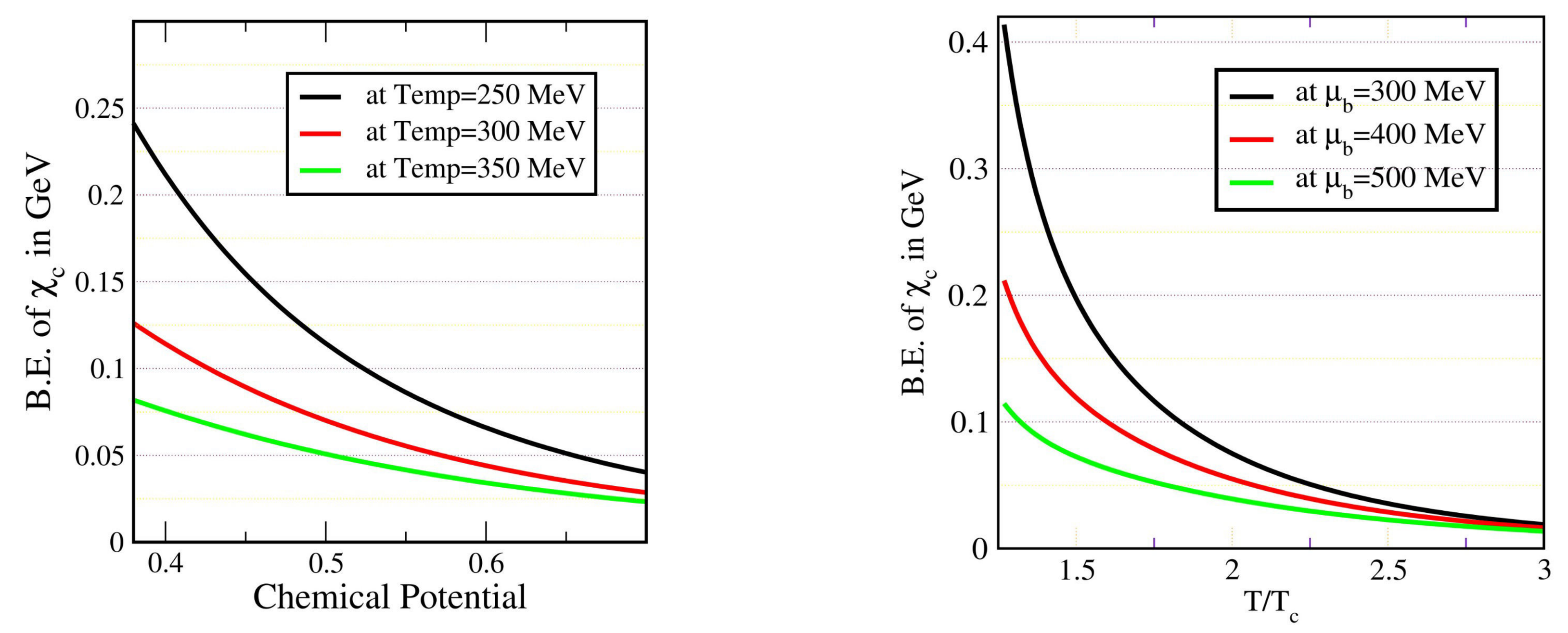

FIG 1. Shows the variation of binding energy of χ_c with chemical potential at different values of temperature (left panel) and with temperature at different values of chemical potential (right panel).

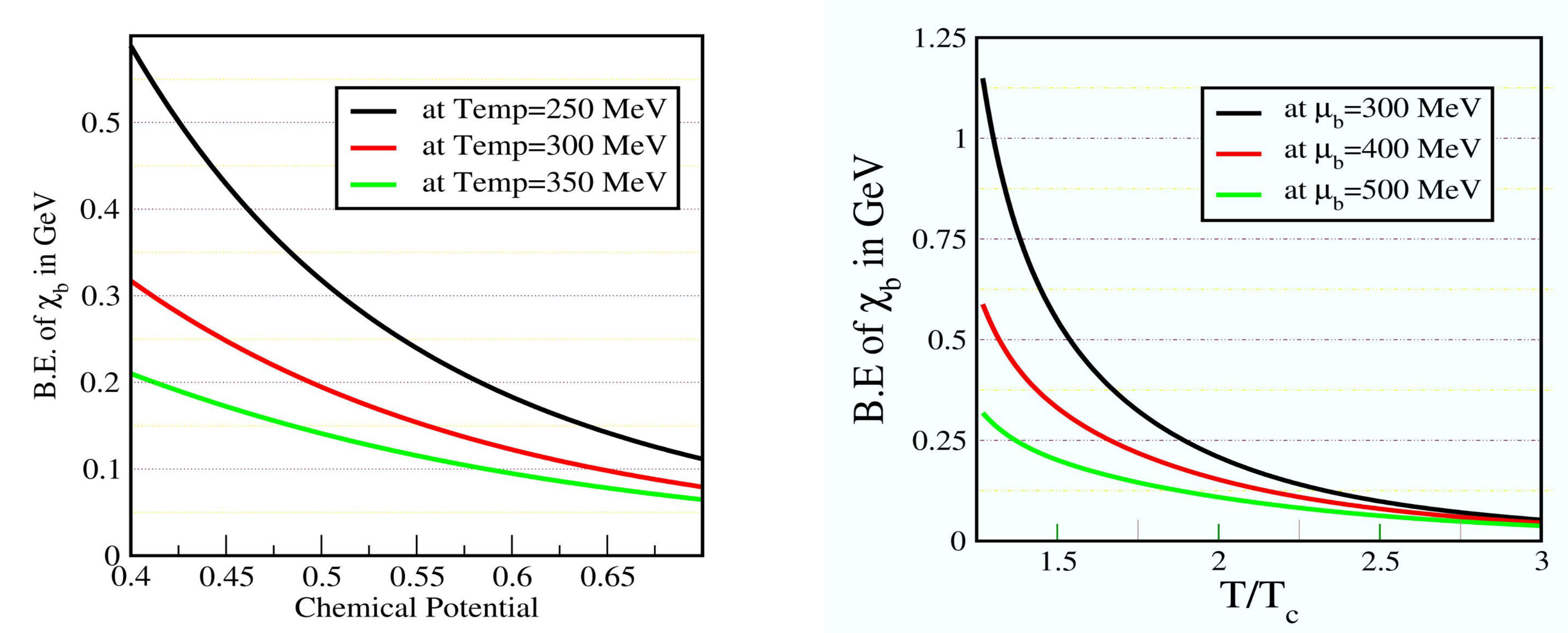

FIG 2. Shows the variation of binding energy of χ_b with chemical potential at different values of temperature (left panel) and with temperature at different values of chemical potential (right panel).

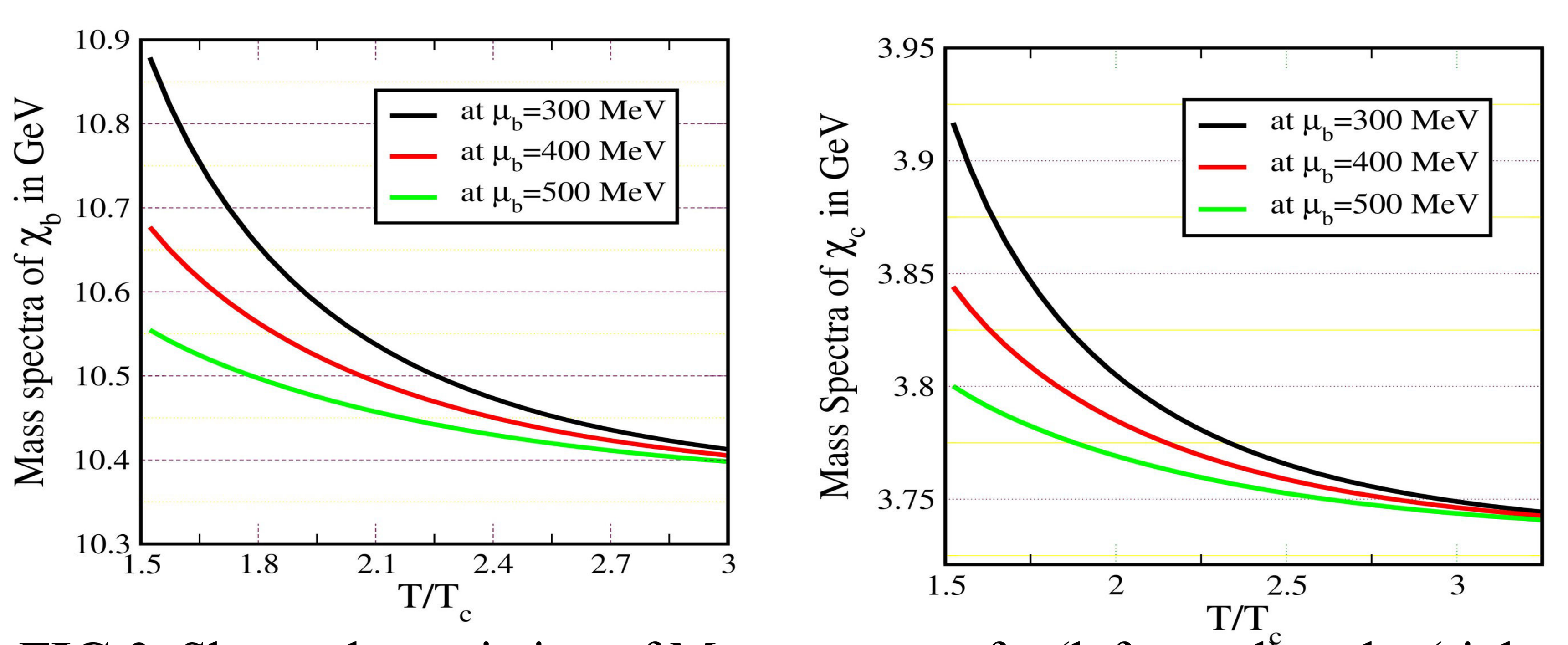

FIG 3. Shows the variation of Mass spectra of χ_b (left panel) and χ_c (right panel) with temperature at different values of chemical potential.

Methodology

The medium modified heavy quark potential which is depends upon temperature as wellas baryonic chemical potential is given as[1]

$$\boldsymbol{V}(r,T,\mu_b) = \left(\frac{2\sigma}{m_D^2(T,\mu_b)} - \alpha\right)\frac{exp(-m_D(T,\mu_b)r)}{r} - \frac{2\sigma}{m_D^2(T,\mu_b)r} + \frac{2\sigma}{m_D(T,\mu_b)} - \alpha m_D(T,\mu_b)$$

On solving Schrodinger equation by putting this potential we get the B.E.

$$E_{(\chi_c,\chi_b)} = E_{(\psi',\gamma')} + E^{corr}_{(\chi_c,\chi_b)} = \frac{m_{(c,b)}\sigma^2}{4m_D^4}\left(1+\frac{2\sigma^2}{3m_D^4}\right)$$

B.E. is the sum of B.E. of Ψ' and ϒ' and correction term[4]. here the string tension (σ) is 0.184 GeV^2. where $m_{(c,b)}$ is the mass of the heavy quarks m_D is the quasi particle Debye mass.[2] and references therein.

$$m_D^2(T,\mu_b) = T^2\left(\frac{N_c}{3}Q_g^2\right) + \left(\left(\frac{N_f}{6} + \frac{1}{2\pi^2}\left(\frac{\mu_b^2}{9T^2}\right)\right)Q_q^2\right)$$

Q_g and Q_q are the effective charges of gluons and quarks

$$Q_g^2 = g^2(T)\frac{6PolyLog[2,z_g]}{\pi^2} \qquad Q_q^2 = g^2(T)\frac{-12PolyLog[2,-z_q]}{\pi^2}$$

Results and Conclusions

In the present work, From fig.1 we have seen that the binding energy for charmonia (1P state) decreases with increasing temperature (left panel) as well as chemical potential (right panel). From fig.2 we have seen that the binding energy for bottomonia (1P state) decreases with increasing temperature (left panel) as well as chemical potential (right panel).
In fig. 3 we have seen that mass spectra for χ_b (left panel) and χ_c (right panel) decreases with increasing temperature as well as chemical potential.

References

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